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A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

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DIVISION OF CHEMISTRY

Variations in Vitamin A and Chemical Composition of Corn

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*Dean School of Veterinary Medicine.
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Deficiency of vitamins, protein, energy, or minerals, in the diet of man or animals may result in decreased health and vigor or in certain diseases. Vitamins are organic compounds found in foods in very small quantities, and are essential to the life and health of animals. Albino rats are used to estimate the quantity of vitamins in foods. Methods are described for breeding the rats and testing the foods for vitamin A. Selection of the breeding rats resulted in improvement in uniformity.

The vitamin A content of yellow corn is high. One gram of yellow corn (39 samples) contained 2.5 to 8 units of vitamin A, one gram of red or variegated corn (18 samples) contained 0.9 to 5 units, while one gram of white corn usually contained less than .03 unit. The units of vitamin A in crosses of yellow with white corn were approximately in proportion to the number of genetic factors for yellow color in the crosses. Season and locality (11 localities and 3 seasons) had some effect on the vitamin A content of yellow and of red corn.

Varieties of corn varied little in composition, including protein, but the protein content varied considerably according to the locality in which the corn was grown. The correlation between rainfall, January through July, and protein content was $-.576 \pm .072$. Slightly less lime and phosphoric acid were in the corn grown in two localities than in the samples grown at the other five places.

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VARIATIONS IN VITAMIN A AND IN CHEMICAL COMPOSITION OF CORN

G. S. FRAPS

Sufficient energy, proteins, vitamins, and minerals, such as phosphoric acid, lime, magnesia, sodium, chlorine, sulphur, potash, iron, copper, iodine, and fluorine must be furnished by the diet of man and animals, according to recent investigations. Deficiencies in diet may cause retardation in growth of young animals, deficiency of production such as milk, or eggs, lack of vitality or vigor; or may lead to diseases such as xerophthalmia, pellagra, scurvy, anemia, rickets, and goiter, as well as susceptibility to other diseases such as pneumonia or tuberculosis, or to decreased ability to reproduce.

Vitamins are organic substances which are present in very small quantities in foods, and are known to be essential to the health of animals. Vitamins vary in amounts in different foods. A particular food may contain a large amount of one vitamin, while the amount of one or more of the others may be very low, or it may be almost entirely absent. A deficiency of any vitamin in the diet may result in failure of young animals to grow, disturbances of bodily function, disturbances of health, or even in serious diseases such as rickets, scurvy, or beri-beri.

Vitamin A was one of the first vitamins discovered. It occurs in large quantity in yellow corn, while little or none is found in white corn.

For the purpose of this study, samples of corn grown at the various substations in different parts of the state were furnished by the Division of Agronomy. Chemical analyses were made in addition to the estimation of vitamin A; and as the analyses bring out some points of interest, they also are discussed in this Bulletin.

VITAMINS AND THEIR IMPORTANCE

As previously stated, vitamins are organic substances found in small amounts in foods, and are essential to the health or proper functioning of the animal body. The exact number of vitamins is not known, since new ones are being discovered from time to time and those now considered as single vitamins may later be split into two or more. Vitamins are studied by means of experiments on animals; and complete or partial lack of one of them is recognized by the failure of the animal body to perform some of its functions. The following is a brief description of the vitamins (19) known at present.

Vitamin A. This is called also fat-soluble A, or the anti-xerophthalmic vitamin. It is essential for bodily health and growth. An eye trouble

called xerophthalmia frequently occurs when vitamin A is not consumed in sufficient amounts. Young animals do not grow well when the diet is deficient in vitamin A, and also are likely to suffer from the sore eyes referred to above, or from other disorders. Vitamin A is abundant in such foods as green vegetables, milk, butter, and yellow corn. The amount is low in rice, wheat flour, white corn, oats, and other foods.

Vitamin B Complex. What was called Vitamin B a short time ago, is now believed to comprise at least three vitamins of which two have each been given three different names. (B, B_1 or F; B_2, G or P-P; B_3 and possibly B_4.) So much work has been done and apparently is still being done on the complex termed vitamin B, that it would introduce much confusion to retain the term vitamin B for one of the constituents of the vitamin B complex. In accordance with the proposal of S. L. Smith (18, see also 3), the two chief constituents of the vitamin B complex are here termed vitamin F and vitamin G.

Vitamin C. Vitamin C is also termed the anti-scorbutic vitamin. Deficiency of vitamin C results in a disease known as scurvy. This disease was formerly of frequent occurrence in time of famine or on long sea voyages and it occurred also during the world war. For over a hundred years it has been known that lemons or vegetables would prevent scurvy. Vitamin C occurs in large quantities in tomatoes, raw cabbage, turnips, and citrus fruits, especially lemons and grapefruit. Wheat flour, corn meal, oat meal and similar cereals contain little vitamin C. It may be destroyed by cooking.

Vitamin D. This is also called the anti-rachitic vitamin. Deficiency of vitamin D results in imperfect assimilation of lime in the bones, causing young animals or children to suffer from rickets, one symptom of which is soft bones. A deficiency of vitamin D may also be conducive to decay of the teeth. Vitamin D occurs in liver, egg yolk, and in small amounts in milk and butter. The compound formed by exposure of oils or certain vegetable waxes to ultra-violet light rays acts in the same way as vitamin D. Sunshine takes the place of vitamin D. Animals or people who get plenty of sunshine should not suffer for deficiency of vitamin D. With the abundance of sunshine available in Texas, there is little reason for children or animals to suffer from rickets, although it does occur. Cod liver oil is rich in vitamin D.

Vitamin E. This is the reproductive vitamin, and is needed for the reproduction of animals. Deficiency of this vitamin results in sterility. Vitamin E is widely distributed, being present in wheat, oats, milk, certain vegetable oils, lettuce, and other foods.

Vitamin F. Vitamin F is the anti-neuritic vitamin, soluble in water, and destroyed partly or completely by heat (1). Its presence is required to prevent polyneuritis in birds and animals, and possibly beriberi in man. This vitamin has also been termed vitamin B_1, or vitamin

B. Complete absence of vitamin F is followed by loss of appetite, loss of weight, and a condition of nervousness. It is found in wheat, corn, yeast, rice polish, and in other foods.

Vitamin G. (5) This is known as the anti-pellagric vitamin and is a water-soluble vitamin, not easily destroyed by heating. When the ration of young rats is dificient in this vitamin, there occurs a rapid decrease in rate of growth. Older animals may lose weight. The rats also become weak and may develop skin lesions, which are symptoms like those which occur in pellagra. Cereal grains are poor in vitamin G, while milk and green leafy vegetables seem to be better supplied with it.

Vitamin B_3. (4) This is a water-soluble vitamin, recently discovered in the vitamin B complex. It is destroyed by heat. It is necessary for the growth or recovery in weight of birds, but does not seem to be needed by rats. Yeast, whole grains, and malt are good sources of vitamin B_3; beef and beef liver are fair sources; milk, orange and tomato juice, spinach, potato juice, and corn molasses are somewhat low in this vitamin.

Vitamin B_4. (4) This has been reported as present in the vitamin B complex but little definite information is available regarding it. It is similar to B_3 but is needed by rats, while B_3 is needed by birds but not by rats.

VITAMIN A IN CORN

Steenbock in 1919 (14) first showed that yellow corn contains a much higher content of vitamin A than does white corn. Steenbock and Coward in 1927 (15) found corn deficient in vitamin D. Rocke and Hetler in 1928 (10) studied the vitamin A in corn and its distribution in the by-products from the manufacture of starch. The greater part of vitamin A was located in the pigmented layer of the endosperm. Corn bran and grits were deficient in vitamin A.

Only a few quantitative determinations of the content of vitamin A in corn have been made. M. C. Smith (16, 17) in 1930 found that 0.3 gram of yellow corn contains one unit of vitamin A compared with about 5.5 gm. for hegari and 3 gm. for yellow milo. Russell (11) found about 0.5 gram of yellow dent corn contained one unit of vitamin A, while white-topped yellow dent contained one unit in 0.75 gm. Hauge and Trost (6) compared the growth of rats on five lots of corn of different breeding and concluded that the vitamin A was transmitted exclusively with the genetic factors for yellow endosperm. Meyer and Hetler (4) studied the vitamin A concentration in the by-products from the manufacture of starch.

METHODS OF ESTIMATING VITAMIN A

While colorimetric tests have been proposed for the estimation of vitamin A, they cannot be considered reliable. It is necessary to use

biological methods for the detection and estimation of vitamins. Rats, rabbits, guinea pigs, pigeons, chickens, and other animals are used.

Two methods were used for the estimation of vitamin A in the work reported here. In both methods, the amount of vitamin A was measured by the growth of rats. One method, here termed the ration method, consists of feeding the animal an unlimited quantity of a ration presumably sufficient in all nutritive factors except vitamin A, in which vitamin A is supplied only by the food to be tested. This is the older method. The other method, here termed the unit method (12, 13), consists in feeding rats previously freed of vitamin A, a weighed amount of the feed to be tested, in connection with a ration complete except for vitamin A. Both methods depend upon the gain in weight of the rats, and as the growth of rats is subject to other factors such as capacity to grow and infections or other diseases, the methods do not possess the exactness of chemical analysis.

Standardization and Care of Rats

The rats used were progeny of Albino rats obtained from the Wistar Institute, and from the Albino Supply Company, Philadelphia. The rats were paired and kept in cages of wire cloth, 12 inches wide, 18 inches long, and nine inches high. These cages were placed over pans on wooden stands constructed in such a way as to hold sixteen cages in four tiers, an arrangement that allows the cages to be taken down readily for cleaning. An automatic watering device kept the rats supplied with water, and a satisfactory ration was kept before them. Pieces of bone were given them on which they could grind their teeth. Potatoes, lettuce, or canned spinach were given once a week. The ration which was found to be satisfactory, was as follows:

Corn meal	1200 grams
Cottonseed meal	200 grams
Powdered whole milk	600 grams
Alfalfa meal	40 grams
Sodium chloride	10 grams
Calcium carbonate	10 grams

An analysis of one sample of this mixture follows:

Protein	17.14
Fat	8.17
Crude Fiber	2.45
Nitrogen-free Extract	60.14
Moisture	8.86
Ash	2.45

The system of selecting and keeping up the stock of breeding rats was as follows:

Ten pairs of rats which came as nearly as possible within the following requirements were selected and mated each month:

(a) The parent should have raised two litters in four months.

(b) Sixty per cent of litters should have been suitable for experimental work.

(c) The parents should not have produced more than three litters when the young were selected for breeding.

(d) The selected rats should be healthy.

Thirty young rats were chosen carefully each month, weighing 35 to 45 grams when 21 to 28 days of age.

Females and males were kept separately until grown, in large cages 24 inches by 18 inches by 9 inches, provided with circular revolving discs for exercising.

At the age of 120 days, suitable rats weighing 160 to 180 grams in the case of females and 220 to 250 grams in the case of males, were paired in regular breeding cages.

Breeding rats that failed to produce offspring for a period of 3 months were destroyed.

In this way the stock has been successfully replenished and a continuous supply of young rats made available, the larger proportion of which falls within the weight required for the experimental work. The system of selection described was more successful than anticipated. At the beginning of the work, 40 to 50 per cent of the young rats were too small or too large for the requirements of the work. By the end of two years, practically all the young rats could be used in the experiments.

In the fall of 1929, the pair system of breeding described above was compared with the group system used at the Pennsylvania Station. In the group system, one male and four females are placed in large breeding cages. The rats are numbered by marks on the ears. Pregnant females are isolated in individual cages. After the young are weaned, the female is placed with other females for a resting period of 14 days before being returned to the cage containing the same male to which she was previously mated.

The results of comparison of the two methods for four months are given in Table 1. While more rats were born by the pair method than by the group method, a smaller number was raised. The superiority of the group method was probably due to the period of isolation from the male and the rest given the female. The new system also had the advantage of requiring a smaller number of males and a smaller number of cages. The entire colony was placed on the group system in March, 1930.

Table 1.—Number of rats by the paired method and by the group method.

	Paired method	Group method
Number of females	45	46
Number of young rats	371	313
Number of rats raised	107	188
Percentage raised	29	60
Average number of rats raised per female	2.4	4.1

Details of the Ration Method for Estimating Vitamin A

In the first series of tests, the method here called the ration method was used for comparing the amounts of vitamin A in the different samples. In this method, the young rats were fed a mixture complete as nearly as possible in all respects except in vitamin A. It should contain the vitamin A only in the sample to be tested. The rats were allowed to eat freely of the ration, and the amount of vitamin A was measured by the gain in weight over a period of 8 weeks or more.

At first the immediate objective was to secure a ration that would give normal growth over an experimental period of approximately three months. With this object in view, response in growth to varying amounts of protein, carbohydrate, fat, salts, and yeast was determined. Casein proved a satisfactory protein but unfortunately the crude casein contains appreciable traces of the vitamins associated with milk and it was necessary, therefore, to purify it by extraction with a suitable solvent or otherwise. It was boiled with a mixture of equal parts of ether and alcohol for one hour under a reflux condenser; after three successive extractions the extracted casein was filtered off by suction and dried at 100 degrees C.

The requisite minerals were supplied by using a modification of the salt mixture of Osborne and Mendel, which was prepared as follows:

Salt Mixture 7015

Dicalcium phosphate	180	gm.
Potassium sulphate	17	gm.
Potassium chloride	111	gm.
Calcium carbonate	30	gm.
Magnesium carbonate	24	gm.
Sodium carbonate	34	gm.
Potassium carbonate	35	gm.
Citric acid	111	gm.
Iron citrate (or ferrous sulphate 2 gm.)	6	gm.
Potassium iodide (1 gm. in 500 cc., take 10 cc.)	.02	gm.
Manganese sulphate (4 gm. in 500 cc., take 10 cc.)	.08	gm.
Sodium fluoride (12.5 gm. in 500 cc., take 10 cc.)	.25	gm.
Potash alum (1 gm. in 500 cc., take 10 cc.)	.02	gm.

All the salts were finely powdered, and then mixed well. The solutions to be used were placed in an evaporating dish; 100 cc. water added, and mixed well with the salts; the mixture was dried in a steam bath, and then powdered.

Fleischmann's stock yeast was found to give satisfactory results as a source of vitamin B when 10 per cent was used. With smaller percentages the rats began losing weight at the end of 5 or 6 weeks instead of gaining.

The following ration was used in the experiments (Mixture 639):

Salt mixture (Method 7015)	8 parts
Casein (purified)	32 parts
Yeast	10 parts
Wesson oil (cottonseed oil)	20 parts
Corn to be tested	130 parts

The technique employed was as follows: Four or more young rats 23 to 26 days old and weighing 38 to 42 grams, were placed in circular experimental cages (tinned test-tube baskets) standing on 10-inch soup plates, two of the same sex being placed in each cage. The rats did not have access to their excretions, which contain vitamin A. Samples of corn were fed freely in Mixture 639 in granite-ware cups, so that the rats had all they could eat. The weights of the rats and of the food eaten were recorded each week.

A number of checks were run in the course of the work, by substituting 2 per cent of cod liver oil for 2 per cent of Wesson oil in the ration mentioned above (No. 639), both with starch and with several of the different varieties of corn. The checks gave satisfactory results, as the rats grew well.

Origin of Corn Used. The samples of corn were secured from the various experimental farms through the Division of Agronomy. The soil type, on which the corn was grown, year of collection, and fertilizer used are given below.

Beaumont, No. 4—Lake Charles clay loam and Crowley clay, 1926-7-8-9, no fertilizer.

Nacogdoches, No. 11—Kirvin clay loam, 1926.
Kirvin fine sandy loam, 1927, 1928, 1929. Fertilized in 1926; fertilized with 300 pounds of 4-12-2 in 1927, 1928; 400 pounds of 6-9-3 in 1929.

Angleton, No. 3—Lake Charles clay loam, 1926, 1927, 1928.
Lake Charles fine sandy loam, 1929. No fertilizer, 1926, 1927; 100 pounds of superphosphate in 1928; 200 pounds of 18 per cent superphosphate in 1929.

Troup, No. 2—Susquehanna fine sandy loam. No fertilizer in 1926; 240 pounds superphosphate, 100 pounds of cottonseed meal and 60 pounds of nitrate of soda in 1927; 300 pounds of superphosphate, 100 pounds of nitrate of soda at planting; 150 pounds of nitrate of soda as side dressing in 1928; 200 pounds of 16 per cent superphosphate and 100 pounds of nitrate of soda in 1929.

Temple, No. 5—Houston clay, no fertilizer.

Weslaco, No. 15—Victoria fine sandy loam, no fertilizer.

College Station (Main Station)—Lufkin fine sandy loam; 300 pounds of 3-12-3 in 1926, 1927, 1928; 300 pounds of 3-10-3 in 1929.

Lubbock, No. 8—Amarillo fine sandy loam, 1926.
Richfield fine sandy loam, 1927 and 1929; no fertilizer.

Denton, No. 6—San Saba clay; no fertilizer.
Chillicothe, No. 12—Kirkland clay loam, 1928. Vernon fine sandy loam, 1929. No fertilizer.
Iowa Park, No. 16—Yahola very fine sandy loam, 1926. Miller loam, 1927. No fertilizer.
Beeville, No. 1—Goliad fine sandy loam, 1926, 1927, 1929.
Poesta fine sandy clay loam, 1928.

RESULTS WITH THE RATION METHOD

Table 2 contains the detailed results of some of the experiments, while average results are given in Table 3. The results are summarized in Table 4, which gives the average gain in weight of the rats for the period of 8 to 11 weeks, if they survived that long. These results show that white corn contains less vitamin A than yellow corn, and that strawberry corn is intermediate between the two. It also shows that white corn grown at some places contains more vitamin A than that grown in other localities. In some cases the white corn seemed to give as good a growth as the yellow, but this may be due to defects of the method, especially as the young rats are known to contain vitamin A. The Chisholm white corn from Beaumont gave growth exceeding that of all except one of the samples of Ferguson yellow dent. Surcropper (white) from Beaumont gave slightly more growth than Ferguson yellow dent from Beeville. Fentress strawberry (variegated) from Beaumont, Denton, and Troup gave more growth than most of the samples of Ferguson yellow dent. The Beaumont and Denton samples in general were more potent than the others.

These results will be mentioned further in connection with the discussion of the results secured in subsequent years, by the use of the unit method. The more accurate results obtained by unit method did not confirm those results obtained by the ration method, which had assigned a high vitamin A content to white corn.

THE UNIT METHOD

The ration method has the advantage of following the usual procedure of feeding animals, but the amount eaten of the feed to be tested varies with the appetite of the animal and also with its capacity to eat. As the animal grows larger it eats a larger quantity of food each day and thus receives a larger amount of vitamin A. The quantity of vitamin A fed varies with the appetite of the animal. Likewise, rats contain a considerable store of vitamin A at the beginning of the test and this aids in the growth of the rat. The amount of vitamin A stored in the rat varies with the character of the feed fed, and with the individuality of the animal.

The method developed by Sherman and Munsell (here termed the unit method) (13, see also 8 and 15) was studied for the purpose of applying it to this particular problem. This method consists in feeding

Table 2.—Details of some of the experiments with individual rats on vitamin A in corn with the ration method.

Registration No.	Description	Begin, grams	End, grams	Gain, grams	Gain per week, grams	Length of period, weeks	Health	Sex
25753	Hastings Prolific, Troup, Texas	44	165	121	11.0	11	Normal	F
	Hastings Prolific, Troup, Texas	44	140	96	8.7	11	Normal	F
	Hastings Prolific, Troup, Texas	43	149	106	9.6	11	Normal	F
	Hastings Prolific, Troup, Texas	43	136	93	8.5	11	Normal	F
	Average			104	9.5			
25754	Ferguson Yellow Dent, Troup, Texas	40	159	119	10.8	11	Normal	F
	Ferguson Yellow Dent, Troup, Texas	39	168	129	11.7	11	Normal	F
	Ferguson Yellow Dent, Troup, Texas	43	160	117	9.0	13	Dead	F
	Ferguson Yellow Dent, Troup, Texas	42	104	62	5.6	11	Poor	F
	Ferguson Yellow Dent, Troup, Texas	40	173	133	12.1	11	Poor	F
	Ferguson Yellow Dent, Troup, Texas	40	182	142	12.9	11	Poor	F
	Average			117	10.4			
25755	Surcropper, Troup, Texas	44	100	56	7.0	8	Dead	F
	Surcropper, Troup, Texas	43	119	76	7.6	10	Dead	F
	Surcropper, Troup, Texas	42	70	28	2.5	11	Eyes infected	F
	Surcropper, Troup, Texas	40	84	44	7.3	6	Dead	F
	Average			51	6.1			
25756	Bloody Butcher, Troup, Texas	39	160	121	11.0	11	Fair	F
	Bloody Butcher, Troup, Texas	39	146	107	9.8	11	Fair	F
	Bloody Butcher, Troup, Texas	39	145	106	9.6	11	Fair	F
	Bloody Butcher, Troup, Texas	40	138	98	8.9	11	Fair	F
	Average			108	9.8			
25757	Fentress Strawberry, Troup, Texas	40	173	133	11.1	12	Normal	F
	Fentress Strawberry, Troup, Texas	38	163	125	10.4	12	Normal	F
	Fentress Strawberry, Troup, Texas	38	215	177	14.8	12	Normal	M
	Fentress Strawberry, Troup, Texas	43	200	157	13.1	12	Normal	M
	Average			148	12.4			
25758	Oklahoma White Wonder, Troup, Texas	40	90	50	5.6	9	Dead(sore eyes)	F
	Oklahoma White Wonder, Troup, Texas	39	74	35	3.5	10	Dead(sore eyes)	F
	Oklahoma White Wonder, Troup, Texas	42	97	55	5.5	10	Dead	M
	Oklahoma White Wonder, Troup, Texas	42	92	50	4.5	11	Dead(sore eyes)	M
	Average			48	4.8			

Table 2.—Details of some of the experiments with individual rats on vitamin A in corn with the ration method—Continued.

Registration No.	Description	Begin, grams	End, grams	Gain, grams	Gain per week, grams	Length of period, weeks	Health	Sex
25759	Chisholm, Troup, Texas	39	185	146	12.2	12	Normal	M
	Chisholm, Troup, Texas	40	174	134	11.2	12	Normal	M
	Chisholm, Troup, Texas	40	174	134	11.2	12	Normal	M
	Chisholm, Troup, Texas	38	144	106	8.8	12	Fair	M
	Average			130	10.9			
25760	Thomas, Troup, Texas	40	120	80	7.3	11	Dead	M
	Thomas, Troup, Texas	39	80	41	4.5	9	Dead (lungs)	M
	Thomas, Troup, Texas	40	117	77	7.0	11	Dead (sore eyes)	F
	Thomas, Troup, Texas	40	102	62	6.9	9	Dead (sore eyes)	F
	Average			65	6.4			
25793	Oklahoma White Wonder, Denton, Texas	44	156	112	8.6	13	Sore eyes	F
	Oklahoma White Wonder, Denton, Texas	44	154	110	8.5	13	Fair	F
	Oklahoma White Wonder, Denton, Texas	40	134	94	7.8	12	Poor	F
	Oklahoma White Wonder, Denton, Texas	40	167	127	10.6	12	Fair	F
	Average			111	8.9			
25794	Ferguson Yellow Dent, Denton, Texas	38	168	130	10.0	13	Fair	F
	Ferguson Yellow Dent, Denton, Texas	43	188	145	11.2	13	Fair	F
	Ferguson Yellow Dent, Denton, Texas	44	204	160	13.3	12	Good	F
	Ferguson Yellow Dent, Denton, Texas	43	225	182	15.2	12	Good	F
	Average			154	12.4			
25795	Local Squaw Corn	40	248	208	16.0	13	Good	M
	Local Squaw Corn	44	254	210	16.2	13	Good	M
	Local Squaw Corn	41	155	114	9.5	12	Sore eyes	F
	Local Squaw Corn	42	115	73	6.1	12	Sore eyes	F
	Average			151	12.0			
25796	Surcropper, Denton, Texas	44	143	99	7.6	13	Fair	M
	Surcropper, Denton, Texas	43	118	75	5.8	13	Fair	M
	Surcropper, Denton, Texas	41	134	93	8.5	11	Sore eyes	M
	Surcropper, Denton, Texas	42	140	138	12.5	11	Sore eyes	M
	Average			101	8.6			

25797	Bloody Butcher, Denton, Texas	43	255	212	19.3	11	Lungs	M
	Bloody Butcher, Denton, Texas	44	232	188	17.1	11	Lungs	M
	Bloody Butcher, Denton, Texas	39	220	181	16.5	11	Good	F
	Bloody Butcher, Denton, Texas	38	75	39	3.5	11	Dead	F
	Average			155	14.1			
25798	Chisholm, Denton, Texas	41	154	113	10.3	11	Fair	F
	Chisholm, Denton, Texas	43	136	93	8.5	11	Sore eyes	F
	Chisholm, Denton, Texas	40	120	80	6.7	12	Sore eyes	M
	Chisholm, Denton, Texas	40	145	105	8.8	12	Sore eyes	M
	Average			98	8.6			

Table 3.—Average results for vitamin A in corn by the ration method on rats.

Laboratory No.	Variety and location	Initial weight, grams	Average gain in period, grams	Average gain per week, grams	Number of weeks	Number of rats	Health
25799	Fentress Strawberry, Denton	42	149	12.9	11.5	4	Good
25800	Brazos White, Denton	39	94	8.5	11	4	Poor
25839	Tuxpan, Beaumont	42	97	9.6	10.5	4	Poor
25840	Ferguson Yellow Dent, Beaumont	40	153	14.6	10.5	4	Fair
25841	Chisholm, Beaumont	42	166	13.8	12	4	Good
25842	Hastings Prolific, Beaumont	42	168	12.9	13	4	Good
25843	Surcropper, Beaumont	42	145	10.7	12.5	4	Good
25844	Fentress Strawberry, Beaumont	42	159	12.7	12.3	3	Fair
25845	Thomas, Beaumont	41	115	10.0	10.8	4	Fair
25792	Thomas, Denton	39	103	9.2	11	4	Poor
25851	Chisholm, Angleton	42	62	4.9	12.3	4	Poor
25852	Hastings Prolific, Angleton	39	69	5.6	12.5	4	Poor
25853	Brazos White, Angleton	40	101	8.4	12.3	4	Fair
25854	Oklahoma White Wonder, Angleton	38	95	8.2	6.3	4	Dead
25855	Tuxpan, Angleton	39	77	6.8	11.3	4	Dead
25946	Blue Grain, Nacogdoches	41	50	5.3	10	4	Dead
25947	Surcropper, Nacogdoches	39	68	7.3	10.5	4	Poor
25948	Thomas, Nacogdoches	39	112	8.9	14	4	Poor
25949	Chisholm, Nacogdoches	40	105	4.8	12.5	4	Fair
25860	Thomas, Angleton	39	64	5.0	13.5	4	Poor
25919	Surcropper, Iowa Park	39	84	6.0	14	4	Poor
25920	Fentress Strawberry, Iowa Park	38	144	10.7	13.3	4	Good
25921	Horton, Iowa Park	36	122	8.1	13.3	4	Good
25922	Ferguson Yellow Dent, Iowa Park	37	157	11.2	14	4	Good

Table 3.—Average results for vitamin A in corn by the ration method on rats—Continued.

Laboratory No.	Variety and location	Initial weight, grams	Average gain in period, grams	Average gain per week, grams	Number of weeks	Number of rats	Health
25923	Mexican June, Iowa Park	35	72	5.3	13.5	4	Poor
25924	Chisholm, Iowa Park	38	106	7.6	14	4	Poor
25925	Chisholm, Beeville	39	58	4.8	13	4	Poor
25926	Surcropper, Beeville	36	102	7.3	14	4	Poor
25927	Reese Drouth Resister, Beeville	32	80	6.4	14	3	Good
25928	Horton, Beeville	34	107	7.7	14	4	Poor
25929	Oklahoma White Wonder, Beeville	36	73	6.1	11.8	4	Poor
25930	Hastings Prolific, Beeville	37	35	3.0	10.8	4	Poor
25931	Fentress Strawberry, Beeville	36	125	8.9	14	4	Fair
25932	Ferguson Yellow Dent, Beeville	41	151	10.9	14	4	Good
	Deficiency Ration	40	19	1.4	13	4	Dead
25945	Oklahoma White Wonder, Nacogdoches	41	137	8.5	16	4	Normal
25950	Nacogdoches, Nacogdoches	37	132	8.7	15	4	Poor
26136	Mexican June, Lubbock	40	149	9.3	15	4	Fair
26137	Fentress Strawberry, Lubbock	40	142	9.4	15	4	Normal
26138	Surcropper, Lubbock	39	118	8.1	12	4	Fair
26140	Chisholm, Lubbock	42	106	7.0	15	2	Fair
26201	Strawberry, College Station	41	108	7.2	15	4	Poor
26202	Ferguson Yellow Dent, College Station	39	132	9.0	14.5	4	Normal
26203	Chisholm, College Station	39	58	4.4	13.3	4	Poor
26141	Pioneer or Squaw Corn, Lubbock	40	110	7.8	14	4	Fair
26142	Ferguson Yellow Dent, Lubbock	42	155	11.0	14	4	Normal
26143	Dwarf Mexican June, Lubbock	42	140	9.4	15	4	Poor
26144	Silvermine, Lubbock	42	110	8.4	13	4	Poor
25933	Thomas, Beeville	40	77	5.5	14	4	Fair
25940	Ferguson Yellow Dent, Nacogdoches	36	170	12.1	14	4	Fair
25941	Brazos White, Nacogdoches	35	114	8.1	14	4	Poor
25942	Horton, Nacogdoches	35	102	7.3	14	4	Good
25943	Fentress Strawberry, Nacogdoches	37	114	8.2	14	4	Good
25944	Hastings Prolific, Nacogdoches	40	111	7.0	16	4	Fair
25710	La France Cream Meal, Dallas	41	85	9.8	9	4	Poor
25711	Blue Bonnet Pearl Meal, Dallas	42	72	7.9	9	4	Poor
25712	Hominy Feed, Dallas	41	96	8.7	11	4	Poor
25713	Whole White Corn, Dallas	40	115	10.5	11	4	Good
	Improved Squaw Corn with cod liver oil	44	157	22.4	7	4	Good
	Hastings Prolific Corn	43	91	13.0	7	4	Fair
	Hastings Prolific Corn with cod liver oil	43	137	19.6	7	4	Good
	Yellow Dent Corn	43	132	18.8	7	4	Good
	Yellow Dent Corn with cod liver oil	42	113	16.1	7	4	Good
	Hickory King White Corn	43	67	9.6	7	4	Poor
	Hickory King Corn with cod liver oil	41	85	14.1	6	4	Poor

Table 4.—Average growth of rats in grams per week (vitamin A) in corn grown at various substations in 1926.

Variety of corn fed	Angleton No. 3	Beaumont No. 4	Beeville No. 1	College Station (Main Station)	Denton No. 6	Lubbock No. 8	Iowa Park No. 16	Nacogdoches No. 11	Troup No. 2
Hastings Prolific (white)	5.6	12.9	3.0	.....	.....	.....	.....	7.0	9.5
Ferguson Yellow Dent	.....	14.6	10.9	.....	12.4	11.0	11.2	12.1	10.4
Surcropper (white)	.....	10.7	7.3	.....	8.6	8.1	6.0	7.3	6.1
Bloody Butcher	.....	.....	.....	.....	14.1	.....	.....	.....	9.8
Fentress Strawberry (variegated)	.....	12.7	8.9	7.2	12.9	9.4	10.7	8.2	12.4
Oklahoma White Wonder	8.2	.....	6.1	.....	8.9	.....	.....	8.5	4.8
Chisholm (white)	4.9	13.8	4.8	4.4	8.6	7.0	7.6	4.8	10.9
Thomas (white)	5.0	10.0	5.5	.....	9.2	.....	.....	8.9	6.4
Local Squaw	.....	.....	.....	.....	12.0	7.8	.....	.....	.....
Brazos (white)	8.4	.....	.....	.....	8.5	.....	.....	8.1	.....
Tuxpan (white)	6.8	9.6	.....	.....	.....	.....	.....	.....	.....
Mexican June (white)	.....	.....	.....	.....	.....	9.3	5.3	.....	.....
Reese Drouth Resister (white)	.....	.....	6.4	.....	.....	.....	.....	.....	.....
Nacogdoches (white)	.....	.....	.....	.....	.....	.....	.....	8.7	.....
Blue Grain (white)	.....	.....	.....	.....	.....	.....	.....	5.3	.....
Dwarf Mexican June (white)	.....	.....	.....	.....	.....	9.4	.....	.....	.....
Silvermine (white)	.....	.....	.....	.....	.....	8.4	.....	.....	.....

a ration free from vitamin A but complete in other respects, until the supply of vitamin A stored in the animal is exhausted, and then feeding weighed quantities of the feed to be tested in connection with the ration free from vitamin A.

The amount of supplemental food which causes an average growth of 3 grams a week for 8 weeks, is said to contain a unit of vitamin A. This unit may be described as an average increase in weight of 3 grams a week over a period of eight weeks, following depletion of the bodily store of vitamin A. The problem is to determine the amount of corn or other feed which, when fed daily for six days a week, enables the rat to maintain one unit of growth or 24 grams in 8 weeks. That amount of corn contains one unit of vitamin A.

It was necessary to feed a basal ration so that the rat was certain to receive sufficient protein, energy, and enough of the essential minerals and vitamins other than vitamin A, in order to make sure that the gain in weight might be attributed only to the vitamin A present in the daily portion of corn.

The Sherman diet deficient in vitamin A (Mixture 666), was first used. This mixture is as follows:

Starch	130 grams
Casein	40 grams
Yeast	20 grams
Salt mixture 7015	8 grams
Sodium chloride	2 grams

The extraction of washed casein with a mixture of ether and alcohol to remove vitamin A was both costly and laborious. Destruction of vitamin A by oxidation appeared to offer a simpler method and one which has proved successful (6a). To purify the casein, it was spread on trays in an electric oven to a depth of one-fourth inch and heated to 110 degrees C. for 24 hours. Air was drawn over the material by means of an electric fan and it was stirred from time to time during the day. The casein inactivated by oxidation was compared with casein purified by extraction, by means of rats fed the mixture given above. Results were satisfactory.

The commercial starch also contained appreciable amounts of vitamin A. Untreated starch, starch extracted with a mixture of ether and alcohol, and starch purified by oxidation were compared by means of rats fed on the mixture mentioned above. Destruction of vitamin A by oxidation was found to be satisfactory.

Steenbock and others have emphasized the necessity of supplying vitamin D in the ration. Experiments were made using corn with irradiated Wesson oil up to the time of cessation of growth and the appearance of symptoms of deficiency in vitamin A. The irradiation had no effect on growth, but since rachitic symptoms may develop at a later date, and to avoid any possibility of deficiency in vitamin D, irradiation of the basal ration was used.

The method used was as follows: Two to six rats 23 to 26 days old were placed in a round wire cage (tinned test-tube basket) with wire screen bottoms and fed Mixture 666. In 4 to 5 weeks the rats usually showed symptoms of deficiency. The first indication was generally a slight accumulation of exudate in the corner of one or both eyes. This was followed by swollen and reddened eyelids and later by extensive exudate. With the appearance of definite xerophthalmia, maintenance or loss in weight was observed. At this time, usually about the thirty-fifth day, the rats were placed in individual cages. When the rats stopped gaining weight, or otherwise showed indications of deficiency of vitamin A, weighed quantities of the feed to be tested were fed daily for eight weeks, unless the rat died before the end of the period.

Considerable experience and care are necessary to know when the rats are ready to be put on test of the feed to be assayed for vitamin A. If the rats are taken too soon, the results will be unsatisfactory. On the other hand, if they are taken too late, advanced pathologic conditions may be established. Generalized infections resulting in the formation of pus in the upper part of the digestive and respiratory tract apparently cannot be cured by feeding methods, regardless of the richness of the diet in vitamin A. Lung trouble is a weakness to which the rat is very susceptible; in fact, a big majority die of it; consequently respiratory infection may be the result of radical organic disability and not due to deficiency at all.

Although the Albino rats used were supposedly homozygous, there was considerable variation in growth. This variation has been recognized by the majority of investigators and is variously attributed to the capacity of the individual to grow, to pathological lesions not attributable to the diet, to the varying amount of feed eaten, to seasonal variation, and perhaps other causes.

Attempts were made to feed such a quantity of material containing vitamin A that the rat made an average gain of 3 grams per week for 8 weeks. It is difficult to estimate the amount of feed required to produce exactly this gain. Usually the estimate of the amount of vitamin A present in the food tested was made from gains near that desired; that is, from one lot gaining less than this amount, and another more than the 3 grams a week. When the rats gained less than 3 grams a week, many of them would die before the period was over. If the average of gains in weight was too far from that desired, it was necessary to repeat the experiment, feeding larger or smaller quantities of the feed to be tested. These repetitions were frequently needed, on account of the difficulty of judging closely the exact amount of the food which should be fed to secure the gain of 3 grams a week. The use of six or more rats in each test was found desirable. Some of them usually died before the test was ended. A sudden drop in weight followed by death was probably not due to deficiency of vitamin A. It was desirable also to make check tests beginning on different days; the results secured at different times did not always agree.

The growth of the rats, up to 6 grams a week, was sometimes found to be in proportion to the quantity of vitamin A fed, but in other cases the rats made unusually large gains when fed a little more than one unit of vitamin A. This is the chief reason why it is desirable to estimate the quantity of vitamin A in the food from the results from two groups of rats, one gaining less than 3 grams a week during the eight weeks, and the other a little more than 3 grams. It is also necessary to consider whether the rats which died suffered from deficiency in vitamin A or from other troubles. In spite of all precautions, however, the results are probably accurate only to 10 to 20 per cent.

Comparison of the Unit Method and the Ration Method

Some of the samples of corn were tested by the ration method and also by the unit method. The results are compared in Table 5. The corn is tabulated in order of content of vitamin A by the unit method, beginning with those samples containing the highest amount. On an average the order is similar, but with some individual samples, the order is decidedly different. The sample which comes first by the unit method, comes third by the ration method. The sample which comes second by the unit method is decidedly the highest by the ration method.

Table 5.—Comparison of unit method for vitamin A with the ration method.

Variety	Grams corn to one unit vitamin A, unit method	Units vitamin A to one gram corn, unit method	Average weekly gain of rats in grams, ration method
Ferguson Yellow Dent corn	0.3	3.3	10.9
Ferguson Yellow Dent corn	0.35	3.0	14.6
Ferguson Yellow Dent corn	0.4	2.5	11.0
Fentress Strawberry	0.6	1.7	10.7
Fentress Strawberry	0.8	1.3	8.9
Fentress Strawberry	1.1	.9	7.2
Brazos White	4+?	.25?	8.4
Mexican June (white)	15+	.07—	5.3
Hastings Prolific (white)	25+	.04—	3.0
Oklahoma White Wonder	25+	.04—	6.1
Horton (white)	25+	.04—	7.3
Hastings Prolific (white)	35+	.03—	5.6
Chisholm (white)	100+?	0	4.4
Blue Grain (white)	100+?	0	5.3

The Sherman-Munsell unit method is decidedly superior to the ration method, since it brings out more clearly the differences in the vitamin A content of the various samples, and provides a much more accurate method for measuring the vitamin A in foods. It requires more time, care, and rats, but the superior accuracy justifies the additional work.

Modification of the Ration for Corn Low in Vitamin A

The samples of white corn were so low in vitamin A that the rats could not eat daily a quantity containing one unit. In order to secure

ingestion of a unit of vitamin per day, the white corn to be tested was added to a mixture containing vitamin A in the form of yellow corn. This mixture, No. 685, consisted of the following:

	Per cent
Casein	14
Salt mixture	4
Yeast	5
Irradiated Wesson oil	2
Yellow corn (29229)	3.75
Added test feed	71.25

When 4 grams of this mixture were fed each day, the rat received .15 gram of yellow corn, which amount was found to contain about 1.0 unit of vitamin A. In addition, the rat received 2.85 grams of the food to be tested in each 4 grams of the mixture. Additional gain above that due to the yellow corn was attributed to the vitamin in the added feed being tested. The estimate of the quantity of vitamin A was made from the results of the test. On account of the small quantity of vitamin A present and the difficulty of measuring it, the number of tests on vitamin A in white corn was restricted, and the results are only approximate.

RESULTS OF TESTS WITH THE UNIT METHOD

Detailed results of some of the experiments are given in Table 6. Records were also made of the condition of the animals and the amount of feed eaten. Average results for a number of the experiments are given in Table 7.

Vitamin A in Yellow Corn

The estimated quantity of corn which contains one unit of vitamin A is summarized for Ferguson Yellow Dent corn in Table 8. The amount of corn containing one unit of vitamin A varied from 0.14 to 0.4 gram; or, to put it another way, one gram of the yellow corn contained 2.5 to 7 units of vitamin A. The corn grown in 1926 contained less vitamin A than in 1927, and this, in turn, less than in 1928, though the differences between 1927 and 1928 were usually small. With one exception (Angleton) there was little difference in the vitamin A content of corn grown in the various places in 1928. In 1927, corn grown at Angleton, Nacogdoches and Temple contained less vitamin A than the others. In 1928, Angleton corn still had the lowest content of vitamin A. Both the season and the locality appeared to have some effect on the vitamin A content of the yellow corn.

The vitamin A in varieties of yellow corn other than Ferguson Yellow Dent was also determined. The results are given in Table 9. The amount of corn which contains one unit of vitamin A varies from .13 to 0.2 gram; or one gram of corn contains 5 to 8 units. This variation is comparatively small. The other varieties of corn tested contained about the same amount of vitamin A as does Ferguson Yellow Dent.

Table 6.—Weights of individual rats in some experiments with vitamin A, unit method.

No.	Variety	Grams corn fed per day	Weight of rats in grams									Gains in gram
			0 weeks	1 weeks	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	
29032	Ferguson Yellow Dent corn...	0.2	102	104	108	120	127	120	130	132	130	28
		.2	92	99	106	99	Dead	.....	.....	.....	.....	7
		.3	90	96	100	108	112	112	114	112	118	28
		.3	78	92	114	117	124	128	124	118	108	30
		.3	106	103	130	124	138	140	141	142	138	32
		.3	85	98	106	112	124	132	134	128	124	39
		.3	85	92	94	102	98	105	104	112	106	21
		.35	48	51	63	62	60	70	66	72	73	25
		.35	56	20	77	82	85	96	100	104	104	48
		.35	60	70	82	87	84	73	69	66	68	8
		.35	60	66	73	74	78	81	88	90	106	46
		.4	76	76	82	92	98	106	116	124	129	53
		.4	92	92	100	128	128	144	144	146	148	56
		.4	65	65	62	56	53	76	86	97	94	29
		.4	92	100	106	116	122	129	124	127	Dead	35
		.4	115	120	130	134	134	146	150	158	160	45
		.4	97	110	120	124	135	140	148	150	150	53
		.8	78	104	126	142	148	159	144	188	.....	110
		.8	70	100	110	123	124	134	136	159	.....	89
		1.0	74	80	88	102	122	131	138	148	148	74
		1.0	76	89	100	113	124	128	130	136	140	74
29038	Ferguson Yellow Dent corn...	0.2	86	78	96	94	100	98	113	118	118	36
		.2	88	88	104	104	105	118	117	120	120	32
		.2	102	119	118	124	136	138	140	152	144	42
		.2	90	106	106	110	114	Dead	.....	.....	.....	24
		.2	102	94	98	92	101	98	96	104	122	20
		.2	73	66	60	72	82	97	90	98	96	23
		.2	67	70	69	75	76	82	85	86	86	19
		.3	80	83	90	100	107	128	132	135	146	66
		.3	90	97	104	111	103	102	108	114	117	27
		.3	69	75	89	97	104	109	109	118	121	52
		.3	72	88	94	101	112	125	135	131	133	61
		.4	72	82	100	113	122	138	136	136	141	69
		.4	61	62	73	105	116	127	132	132	143	82
		1.0	70	82	103	110	119	128	132	134	130	60
		1.0	64	76	90	100	108	118	121	132	138	74
		1.2	76	74	122	142	154	172	178	192	196	120
		1.2	61	76	90	105	108	120	120	128	128	67
29050	Oklahoma Yellow Dent corn..	0.1	80	71	75	77	70	92	90	90	85	5
		.1	86	89	96	100	107	110	106	111	108	22
		.1	73	79	78	74	79	76	77	72	69	—4
		.1	83	86	89	84	83	77	72	73	69	—14

		.15	60	58	69	72	80	87	95	105	108	48
		.15	67	74	77	76	80	92	97	95	84	17
		.15	95	76	84	78	85	71	70	Dead	.....	—25
		.15	91	94	95	90	85	Dead	.....	.....	.....	—6
		.15	61	66	66	60	55	55	54	Dead	.....	—7
		.2	76	70	90	106	114	107	107	112	126	50
		.2	82	92	102	106	113	111	122	128	124	42
		.2	65	64	70	74	82	91	93	95	96	31
		.4	72	84	96	115	126	129	136	141	145	73
		.4	60	64	75	88	106	118	132	139	149	89
		.6	68	68	94	100	106	112	116	125	108	40
		.6	58	66	84	95	100	124	130	142	136	78
		1.0	76	80	90	118	126	132	140	144	150	84
		1.0	66	87	94	118	138	139	168	168	173	117
30484	Ferguson Yellow Dent corn...	0.2	46	51	53	58	58	60	66	67	68	22
		.2	68	64	52	Dead	.....	.....	.....	.....	.....	16
		.2	73	67	62	56	50	51	47	58	54	—19
		.2	59	56	54	62	67	68	68	63	Dead	4
		.22	74	65	83	94	103	106	105	107	101	27
		.22	74	67	65	Dead	.....	.....	.....	.....	.....	—9
		.25	82	90	90	69	76	91	98	Dead	.....	16
		.25	60	56	50	49	45	55	72	77	75	15
		.25	67	72	73	79	74	79	81	90	97	30
		.25	53	57	62	77	84	84	86	90	89	36
		.4	81	89	91	88	78	70	Dead	.....	.....	—11
		.4	88	96	98	96	78	83	74	Dead	.....	—14
		.4	79	82	84	83	84	79	72	68	Dead	—11
		.4	82	84	87	87	88	88	81	81	77	—3
30492	Ferguson Yellow Dent corn...	.15	48	50	.....	45	42	Dead	.....	.....	.....	.....
		.15	92	94	.....	102	100	111	132	132	133	41
		.15	84	88	.....	99	100	100	105	106	109	25
		.15	71	68	.....	67	71	80	88	93	94	23
		.15	76	80	86	92	94	95	96	88	88	12
		.15	66	66	81	92	100	103	98	89	Dead	23
		.2	57	59	69	82	85	90	97	96	102	45
		.2	66	67	75	85	88	104	113	123	135	69
29037	Fentress Strawberry corn.....	.7	90	90	88	94	100	102	100	84	93	3
		.7	94	83	100	109	100	108	122	120	122	28
		.7	70	76	87	92	96	96	93	90	90	20
		.7	70	65	67	77	88	94	100	97	102	32
		.7	93	104	108	106	110	117	116	115	112	19
		.8	79	89	105	110	Dead	.....	.....	.....	.....	31
		.8	89	89	92	Dead	.....	.....	.....	.....	.....	3
		.9	78	85	100	111	105	117	128	129	137	59
		.9	66	73	84	93	103	120	122	137	140	74
		1.0	65	87	97	116	133	152	168	174	178	113
		1.0	58	84	94	112	120	130	125	140	147	91
		1.5	70	74	92	104	124	132	135	158	162	92
		1.5	70	82	100	116	132	134	140	164	167	97

Table 6.—Weights of individual rats in some experiments with vitamin A, unit method—Continued.

No.	Variety	Grams corn fed per day	Weight of rats in grams									Gain in grams
			0 weeks	1 weeks	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	
30485	Fentress Strawberry, Angleton	.6	64	71	80	90	95	93	91	94	92	28
		.6	94	115	117	120	123	121	Dead	.....	.....	27
		.6	64	75	82	87	94	100	100	90	Dead	26
		.6	68	87	101	108	114	123	111	108	112	44
		.6	80	86	91	100	95	91	97	80	Dead	0
		.6	80	95	97	89	92	85	81	83	87	7
		.6	78	75	92	87	90	81	75	64	Dead	14
		.6	73	76	85	90	85	80	Dead	.....	.....	7
		.8	46	48	55	63	75	82	90	100	108	62
		.8	56	62	74	82	87	94	98	108	115	59
		.8	84	88	90	82	78	78	71	66	60	24
		.8	100	104	104	97	103	96	97	104	84	16
		.8	98	100	102	99	100	94	96	97	92	6
25930	Hastings Prolific corn*.....	.5	68	68	Dead	.....	.....	.....	.....	.....	.....	0
		.5	61	66	Dead	.....	.....	.....	.....	.....	.....	5
		2.85*	74	92	100	114	.....	.....	.....	106	100	26
		2.85*	86	96	110	Dead	.....	.....	.....	.....	.....	24
28637	Hastings Prolific corn*.....	2.85	106	120	116	124	122	138	140	140	138	32
		2.85	66	80	93	102	106	107	108	114	Dead	48
		2.85	63	76	78	82	82	92	92	91	103	40
		2.85	78	74	78	Dead	.....	.....	.....	.....	.....	0
28979	Hastings Prolific corn*.....	In 107 3.0	95	113	127	130	126	120	107	Dead	.....	12
		In 107 3.0	96	112	130	136	136	140	148	136	152	56
		2.85	86	90	104	120	131	131	Dead	.....	.....	45
		2.85	88	94	106	112	120	126	130	134	130	42
		2.85	63	76	86	85	95	102	103	104	116	53
		2.85	63	72	79	88	96	106	105	Dead	.....	42
28982	Chisholm corn*.....	1.0	79	87	89	95	92	93	68	Dead	.....	—11
		1.0	86	85	76	68	64	57	Dead	.....	.....	—29
		2.0	91	100	94	Dead	.....	.....	.....	.....	.....	— 3
		2.0	77	84	81	84	83	Dead	.....	.....	.....	6
		2.0	83	90	90	89	83	80	71	Dead	.....	—12
		2.85	82	80	86	92	100	102	88	82	80	—2
		2.85	58	74	90	100	116	128	132	139	149	91
		2.85	40	56	77	84	83	91	94	96	98	58
		2.85	52	65	81	88	92	99	102	104	109	57

		2.85	80	93	107	116	121	132	137	143	141	61
		2.85	82	97	106	111	113	120	123	127	129	47
29042	Oklahoma White Wonder corn*	2.85	83	Dead	.....	.....	.....	.....	.....	.....	.....	6
		2.85	99	94	105	Dead	.....	.....	.....	.....	.....	.....
		2.85	76	82	88	92	90	92	80	Dead	.....	4
		2.85	74	78	84	88	84	Dead	.....	.....	.....	10

*2.85 grams fed with 0.15 gm. yellow corn in Mixture 685.

Table 7.—Average results from feeding tests by the unit method for vitamin A.

No.	Variety and location	Grams fed daily	Number of rats begun	Average weight at beginning	Average gain in weight	Average life, weeks
25859	Ferguson Yellow Dent, Angleton, Tex.	.5	2	71	5	3
		1.0	4	86	71	7.5
		1.5	2	77	129	8
		2	3	92	52	8
25840	Ferguson Yellow Dent, Beaumont, Tex.	.3	6	87	4	5.3
		.6	2	65	88	8
		1.0	2	65	83	8
		1.2	2	64	68	8
		1.5	2	71	113	8
25932	Ferguson Yellow Dent, Beeville, Tex.	.2	2	67	7	5
		.3	4	86	24	6.8
		.6	3	75	59	8
		1.0	5	63	66	7.6
		2	2	56	84	8
		Mix 106				
		4	3	68	103	8
26142	Ferguson Yellow Dent, Lubbock, Tex.	.3	4	95	.....	5.8
		.35	3	69	—9	4
		.4	6	95	28	7
		1.0	5	64	76	7
		1.5	2	69	74	8
		4	3	76	50	7
28636	Ferguson Yellow Dent, Angleton, Tex.	.2	6	109	16	5.7
		.3	3	69	15	8
		.35	4	74	43	4
		.4	2	74	62	8
		.6	2	52	71	8
		.8	2	52	90	8
		1	2	67	67	8
		1.5	2	74	107	8
28645	Ferguson Yellow Dent, Troup, Texas.	.2	9	87	37	8
		.4	2	65	143	8
		.6	2	52	70	8
		.8	2	68	78	7
		1.0	2	62	109	8
		1.5	2	71	126	8
28651	Ferguson Yellow Dent, Denton, Tex.	.2	7	88	25	6.9
		.25	4	91	.....	5.8
		.3	2	74	0	6
		.35	4	66	55	8
		.4	2	83	114	8
		.8	2	76	73	7
		1	2	73	60	8
		1.5	2	55	71	8
28983	Ferguson Yellow Dent, Nacogdoches, Texas.	.2	8	93	—9	6.3
		.3	4	53	15	7.5
		.35	3	79	28	8
		.4	2	73	90	8
		.8	3	70	89	7.7
		1	2	69	76	8
		1.2	2	83	65	8
29032	Ferguson Yellow Dent, Lubbock, Tex.	.2	2	97	18	5.5
		.3	6	91	30	8
		.35	4	56	88	32
		.4	6	90	47	7.8
		.8	2	74	100	7
		1	2	75	74	8
29038	Ferguson Yellow Dent, Beeville, Tex.	.2	7	87	29	7.5
		.3	4	78	52	8
		.4	2	67	76	8
		1	2	67	67	8
		1.2	2	69	94	8

Table 7.—Average results from feeding tests by the unit method for vitamin A—Continued.

No.	Variety and location	Grams fed daily	Number of rats begun	Average weight at beginning	Average gain in weight	Average life, weeks
29050	Oklahoma Yellow Dent, Iowa Park.	.1	4	81	2	8
		.15	5	75	5	6.4
		.2	3	74	41	8
		.4	2	66	81	8
		.6	2	63	59	8
		1	2	71	101	8
29142	Ferguson Yellow Dent, College Station.	.2	5	87	28	8
		.5	2	65	81	7
29229	Yellow Corn, College Station.....	.15	3	72	28	3
		.2	15	84	36	6.5
		.3	7	84	47	8
		.4	3	77	93	8
		.6	4	73	75	8
		.8	10	76	97	8
		1.0	4	83	81	8
		1.2	4	83	101	8
30214	.....	.15	6	83	29	8
		.2	3	57	48	7.3
		.3	3	53	62	8
30215	Golden Harvest, Troup.....	.1	3	78	18	7.3
		.15	4	69	63	6.3
		.2	4	57	55	7.5
		.3	4	60	60	8
30216	Revters Improved Golden, Troup....	.12	3	70	5	8
		.15	4	77	47	6.5
		.2	2	49	60	8
		.3	4	66	64	8
30217	Ferguson Yellow Dent, Troup.....	.13	6	72	9	8
		.15	4	77	41	7.3
		.2	2	61	42	8
		.3	4	56	60	8
30218	Ferguson Yellow Dent, pollinated by Ferguson Yellow Dent, deep yellow color, three factors for endosperm color.	.15	7	83	36	6.6
		.18	4	77	45	7.5
		.2	4	79	3	6
		.3	3	64	53	8
30219	Ferguson Yellow Dent, Pollinated by Surcropper, dilute yellow, two factors for endosperm color.	.15	4	64	21	7
		.2	4	80	4	6.5
		.25	4	64	62	7.5
		.3	2	68	42	8
		.4	2	66	50	8
30220	Surcropper, pollinated by Ferguson Yellow Dent, one factor for endosperm color.	2.0	2	64	89	8
		.3	4	70	21	7
		.4	4	83	.8	5.3
		.5	2	70	66	8
		1	2	64	78	8
30222	Yellow Dent X Surcropper, F. hybrid—deep yellow, three factors for endosperm color.	.12	4	56	11	3
		.14	4	67	17	7.5
		.18	4	62	62	8
		.2	4	73	21	8
		.3	4	69	54	8
30223	Yellow Dent X Surcropper, F. hybrid, dilute and pale yellow, one and two factors for endosperm color.	.15	4	61	7	6
		.2	9	75	94	6.2
		.25	4	63	30	6.3
		.3	4	63	46	6
		.4	2	73	54	7
30270	Nicholson's Giant Yellow, Beeville, Texas.	.2	5	79	31	6.2
		.3	4	60	39	7

Table 7.—Average results from feeding tests by the unit method for vitamin A—Continued.

No.	Variety and location	Grams fed daily	Number of rats begun	Average weight at beginning	Average gain in weight	Average life, weeks
30271	Wood's Golden Harvest, Beeville, Texas.	.12	4	69	17	8
		.15	8	79	47	5.7
		.2	4	89	34	6.3
		.3	4	63	63	8
30272	Reuter's Improved Golden Dent, Beeville, Texas.	.12	4	65	15	7.3
		.15	4	75	45	6.3
		.2	2	71	57	8
		.3	4	67	70	8
30273	Ferguson Yellow Dent, Beeville, Texas.	.15	6	77	26	5.5
		.2	10	78	33	6.5
		.3	4	74	51	7.3
30310	Yellow Dent, Temple, Texas.....	.14	4	68	21	5.5
		.2	5	57	48	7.2
30373	Pilgrim Yellow Dent, Denton, Texas.	.15	4	69	36	7
		.2	4	75	33	8
30385	Bloody Butcher, Denton, Texas.....	.15	4	63	5	8
		.2	3	75	40	8
		.7	2	93	83	8
		.8	2	66	106	5.5
30386	Wright Yellow Dent, Denton, Texas..	.12	3	83	14	6
		.15	3	85	28	7.3
		.2	2	58	50	2
30481	Ferguson Yellow Dent.....	.2	5	78	28	6.8
30482	Yellow Creole, Nacogdoches, Texas...	.12	4	89	3	2.8
		.15	3	75	41	7.3
		.2	4	68	50	7
30483	Yellow Creole, Angleton, Texas.....	.12	4	87	15	5.5
		.15	6	73	30	8
		.2	2	54	53	8
30484	Ferguson Yellow Dent, Angleton, Tex.	.2	4	62	2	6.3
		.22	2	74	27	5
		.25	4	66	27	7.5
		.4	4	83	—10	6.5
30491	Yellow Creole, Main Station Farm...	.15	6	74	36	7
		.2	6	79	24	7.7
30492	Ferguson Yellow Dent, Main Station Farm.	.15	6	73	25	6.5
		.2	2	62	57	8
30493	Ferguson Yellow Dent, Weslaco, Texas	.14	4	78	29	7
		2	2	73	51	8
30494	Yellow Creole, Weslaco, Texas.....	.15	4	62	29	7.5
		.2	4	82	37	8
30496	Improved Golden, Weslaco, Texas....	.15	6	82	10	5.2
		.2	4	81	49	5.8
30720	Oklahoma Yellow Dent, Iowa Park, Texas.	.15	4	70	33	8
		.2	5	69	43	8
30721	Ferguson Yellow Dent, Iowa Park, Texas.	.15	3	75	29	7
		.2	3	63	50	7.3
30224	White (Yellow Dent X Surcropper) Division of Agronomy, F. hybrid, no factors for endosperm color.	In 685 2.5	4	60	3	6
		In 685 3	4	67	23	6
		In 685 4	4	61	60	6.5

Table 7.—Average results from feeding tests by the unit method for vitamin A—Continued.

No.	Variety and location	Grams fed daily	Number of rats begun	Average weight at beginning	Average gain in weight	Average life, weeks
30997	Yellow Corn, Illinois	.1	4	81	16	7
		.12	4	69	12	6.5
		.15	6	80	—5	6.9
		.18	5	79	17	7.2
		.2	4	67	49	8
31944	Ferguson Yellow Dent, pollinated by Ferguson Yellow Dent, deep yellow, three factors for endosperm color.	.12	6	61	25	7.4
		.15	8	72	42	8
		.2	4	91	55	8
31950	F. hybrid, Ferguson Yellow Dent X Surcropper, pale yellow, one factor for endosperm color.	.3	4	77	6	5.3
		.4	4	93	2	6
		.5	4	80	.....	5.7
		.7	4	74	15	3.5
		.9	5	69	35	8
31951	F. hybrid, Ferguson Yellow Dent X Surcropper-White, no factors for endosperm color.	Mix 685 .4	4	56	.....	5
		Mix 687 .4	4	76	.....	4.3
30994	Yellow Corn Germ, Illinois	1	2	71	8	4
		.15	6	71	14	6.2
		.2	8	75	.....	5.3
		.3	4	77	.....	5
		.4	4	79	15	3.8
		.5	5	88	12	5
		1.0	2	83	.....	1
31945	Ferguson Yellow Dent, pollinated by Surcropper, dilute yellow, two factors for endosperm color.	.16	2	95	17	7.5
		.2	7	74	29	7.8
31946	Surcroper, pollinated by Ferguson Yellow Dent, pale yellow, one factor for endosperm color.	685 +.3	4	76	8	6.3
		.4	8	77	18	6.5
		.45	4	92	13	5.5
		.55	5	50	40	7.8
		.7	4	107	11	8
31947	Surcropper, white, pollinated by Surcropper, no factors for endosperm color.	4	1	48	22	8
		Mix 685 4	1	75	.....	7
		Mix 687 4	4	80	.....	4.8
31948	F. hybrid, Ferguson Yellow Dent X Surcropper, deep yellow, three factors for endosperm color.	.3	4	94	15	8
		.14	4	71	.....	6
		.2	6	87	24	7.7
		.25	7	89	35	7.6
31949	F. hybrid, Ferguson Yellow Dent X Surcropper, dilute yellow, two factors for endosperm color.	.3	10	89	18	6.8
		.4	9	73	33	7.1

Vitamin A in Variegated and in Red Corn

One variety of corn, Fentress Strawberry, with variegated or "calico" pericarp, and one with red pericarp, Bloody Butcher, were tested. The results for 18 samples are summarized in Table 10.

The amount of variegated corn which contained one unit of vitamin A varied from .35 to 1.1 grams; or one gram of corn contained 2.9 to 0.9 units of vitamin A. The red corn contained 1.8 to 5.5 units of vitamin A per gram.

Table 8.—Approximate vitamin A in Ferguson Yellow Dent.

Where grown	Grams corn to one unit			Units of vitamin A in one gram corn		
	1926	1927	1928	1926	1927	1928
Angleton	0.4	.35	.25	2.5	2.9	4.0
Beaumont	.35	.....	.....	3.0	.....	.....
Beeville	.3	.20	.18	3.3	5.0	5.5
Lubbock	.4	.24	.....	2.5	4.0	.....
Troup	.....	.16	.14	.....	6.0	7.1
Denton	.....	.20	.....	.....	5.0	.....
Nacogdoches	.....	.35	.....	.....	2.9	.....
College Station	.28	.18	.15	3.6	5.5	6.7
Temple	.....	.28	.15	.....	3.6	6.7
Weslaco	.....	.....	.15	.....	.....	6.7
Iowa Park	.....	.....	.14	.....	.....	7.1

Table 9.—Vitamin A in varieties of yellow corn.

No.	Variety and where grown	Grams corn to one unit	Units vitamin A to one gram corn
29050	Oklahoma Yellow Dent, Substation No. 16, Iowa Park	.18	5.5
29229	Yellow corn, College Station	.15	6.6
30214	Giant Yellow, Substation No. 2, Troup	.15	6.6
30215	Golden Harvest, Substation No. 2, Troup	.13	7.7
30216	Reuter's Improved Golden, Substation No. 2, Troup	.14	7.2
30270	Nicholson's Giant Yellow, Substation No. 1, Beeville	.18	5.5
30271	Wood's Golden Harvest, Substation No. 1, Beeville	.14	7.2
30272	Reuter's Improved Golden Dent, Substation No. 1, Beeville	.14	7.2
30373	Pilgrim Yellow Dent, Substation No. 6, Denton	.14	7.2
30385	Bloody Butcher, Substation No. 6, Denton	.18	5.5
30386	Wright Yellow Dent, Substation No. 6, Denton	.15	6.6
30481	Ferguson Yeoolw Dent, Nacogdoches	.2	5.0
30482	Yellow Creole, Substation No. 11, Nacogdoches	.14	7.2
30483	Yellow Creole, Angleton	.15	6.6
30491	Yellow Creole corn, College Station	.15	6.6
30494	Yellow Creole, Substation No. 15, Weslaco	.15	6.6
30496	Improved Golden, Substation No. 15, Weslaco	.2	5.0
30720	Oklahoma Yellow Dent, Iowa Park	.14	7.2
30997	Yellow Corn, The Quaker Oats Co., Chicago, Illinois	.2	5.0

Table 10.—Vitamin A in Strawberry corn and Bloody Butcher corn.

Where grown in Texas	Grams corn to one unit vitamin A				Units vitamin A to one gram corn			
	1926 Strawberry	1927 Strawberry	1928 Strawberry	1928 Bloody Butcher	1926 Strawberry	1927 Strawberry	1928 Strawberry	1928 Bloody Butcher
Iowa Park	.6	.....	.....	.55	1.7	.....	.....	1.8
Beeville	.8	.7	.....	.35	1.2	1.4	.....	2.9
College Station	1.1	.7	.5	.....	0.9	1.4	2.0	.....
Angleton	.....	.9	.7	.....	.....	1.1	1.4	.....
Troup	.....	.9	.4	.....	.....	1.1	2.5	.....
Nacogdoches	.....	.85	.....	.....	.....	1.2	.....	.....
Lubbock	.....	1.0	.....	.....	.....	1.0	.....	.....
Denton	.....	.....	.35	.18	.....	.....	2.9	5.5
Weslaco	.....	.....	1.0	.....	.....	.....	1.0	.....
Temple	.....	.....	.....	.18	.....	.....	.....	5.5

Both the variegated corn and the red corn were more variable than any variety of the yellow corn. The reason for the lower vitamin content and greater variability in vitamin content of red and of variegated corn as compared to yellow corn probably lies in the fact that neither of the varieties used is homozygous for endosperm color. The red color of the pericarp obscures the color of the endosperm so that varieties with colored pericarp may become mixed in their endosperm color. The Division of Agronomy determined the endosperm color on 56 self-pollinated ears of Fentress Strawberry, the variegated variety, and found that 55.4 per cent of the plants were white-seeded, 32.1 per cent yellow-seeded, and 12.5 per cent were segregating. If vitamin content is completely associated with yellow color this variety should have about 38 per cent as much vitamin as it would have if it were pure yellow. Samples of this variety which are known to be pure for yellow endosperm are now being tested in comparison with samples known to be pure for white endosperm. In the meantime it may be of interest to note that the vitamin content of Strawberry corn in comparison with Ferguson Yellow Dent grown at the same stations was 30.5 per cent, 27.4 per cent, and 28.2 per cent, respectively, for the years 1927, 1928, and 1929.

As with the yellow corn, the red corn grown in 1928 contained the highest amounts of vitamin A, that in 1927 next, and that grown in 1926 the lowest.

Vitamin A in White Corn

As previously stated, the white corn was fed in a complete ration mixed with yellow corn to supply part of the vitamin A needed. Approximate results, on 28 samples, are given in Table 11. The amount of vitamin A in most of the samples of white corn was very low, one unit in 25 to 35 grams. Some few samples, however, contained one unit in 2 to 5 grams of corn, which is high for white corn. This variation may possibly be due to crossing with the yellow corn.

RELATION TO HEREDITY

The yellow pigmentation in the endosperm of corn is known to be inherited in definite Mendelian ratios, and it is possible to produce samples of corn having 0, 1, 2, or 3 genetic factors for yellow endosperm. Samples of corn of known genetic constitution with regard to endosperm color were furnished by Dr. P. C. Mangelsdorf of the Division of Agronomy (6b). The results are given in Table 12. In one test the four types were produced by pollinating Surcropper and Ferguson Yellow Dent by a mixture of pollen from both varieties. In the other test, four types were obtained from the same ears, which were on first-generation hybrids of Ferguson yellow dent and Surcropper.

In the first test the units of vitamin A per gram of corn were approximately in proportion to the number of genetic factors for yellow endosperm. Samples of corn involving 1, 2, and 3 genetic factors contained vitamin A in the proportions 2.5:5:7 in 1928 and 2:5:8 in 1929, the average for the two years being 2.25:5.00:7.50.

Table 11—Vitamin A in white corn

No.	Variety and where grown	Grams corn to one unit vitamin A	Units vitamin A to one gram corn
25852	Hastings Prolific, Substation No. 3, Angleton, Texas	35+	.03
25853	Brazos White, Substation No. 3, Angleton, Texas	4?	.25
28637	Hastings Prolific, Substation No. 3, Angleton, Texas	12	.08
28638	Oklahoma White Wonder, Substation No. 3, Angleton, Texas	0	.00
25929	Oklahoma White Wonder, Beeville, Texas	25+	.04
25930	Hastings Prolific, Beeville, Texas	25+	.04
29039	Surcropper, Substation No. 1, Beeville, Texas	5?	.20
29040	Chisholm, Substation No. 1, Beeville, Texas	22	.05
29041	Hastings Prolific, Substation No. 1, Beeville	25+	.04
29042	Oklahoma White Wonder, Substation No. 1, Beeville, Texas	30+	.03
25942	Horton, Substation No. 11, Nacogdoches, Texas	25+	.04
28979	Hastings Prolific, Substation No. 11, Nacogdoches, Texas	3?	.33
28980	Oklahoma White Wonder, Substation No. 11, Nacogdoches, Texas	2?	.50
28981	Surcropper, Substation No. 11, Nacogdoches, Texas	25+	.04
28982	Chrisholm, Substation No. 11, Nacogdoches, Texas	2	.50
29031	Surcropper, Substation No. 8, Lubbock, Texas	28	.04
25923	Mexican June, Substation No. 16, Iowa Park, Texas	15	.07
29051	Mexican June, Substation No. 16, Iowa Park, Texas	22+	.05
29135	Hastings Prolific, Main Station Farm, College Station, Texas	10	.10
29136	Nacogdoches, Main Station Farm, College Station, Texas	3?	.33
29137	Surcropper, Main Station Farm, College Station, Texas	2?	.50
29138	Oklahoma White Wonder, Main Station Farm, College Station, Texas	22+	.05
29139	Brazos White, Main Station Farm, College Station, Texas	17	.06
29140	Chisholm, Main Station Farm, College Station, Texas	22	.05
29141	Thomas, Main Station Farm, College Station, Texas	5	.50
29143	Horton, Main Station Farm, College Station, Texas	2	.50
29144	Va. White Dent, Main Station Farm, College Station, Tex.	22+	.04

In the second test in which all four types were produced on the same ears the agreement in the ratio was not so close though quite evident. Also all types appeared to be lower in vitamin A than the corresponding lot in the first test.

VARIATIONS DUE TO SEASON AND LOCALITY

It is evident from examination of Tables 8, 9, and 10, that the season has some effect upon the vitamin A content of corn. Both the yellow corn (Table 8) and the red corn (Table 10) contained more vitamin A in 1928 than in 1927, and more in 1927 than in 1926. The differences were large in corn from some places and small at others.

Some influence of the locality is also apparent. Yellow corn grown at Angleton contained (Table 8) less vitamin A than that grown in other localities, in all three seasons. This difference is not so apparent with the red corn. The yellow corn and the red corn grown at Nacogdoches (one season) contained about the same amount as that at Angleton. Corn grown at Lubbock was a little low in vitamin A in the yellow variety one season, a little less than the average in the yellow variety one season, and low in the red variety one season. Consistent relations between the amounts of vitamin A in the corn and the locality in which it was grown are difficult to trace. The differences observed may be partly due to seasonal conditions, and partly to cross pollination.

Table 12.—Units of vitamin A in relation to genetic factors for endosperm color in corn.

Laboratory No.	Seed parent	Pollen parent	Color	No. of genetic factors for yellow endosperm	Grams for one unit of vitamin A	Units vitamin A in one gram
	1928					
30218	Yellow Dent	Yellow Dent	Deep yellow	3	0.14	7
30219	Yellow Dent	Surcropper	Dilute yellow	2	0.2	5
30220	Surcropper	Yellow Dent	Pale yellow	1	0.4?	2.5
30221	Surcropper	Surcropper	White	0	20+	.05
30222	Yellow Dent X Surcropper	Yellow Dent X Surcropper	Deep yellow	3	.16	6
30223	Yellow Dent X Surcropper	Yellow Dent X Surcropper	Dilute and pale yellow	1 and 2	.23	4
30224	Yellow Dent X Surcropper	Yellow Dent X Surcropper		0	20+	.05—
	1929					
31944	Yellow Dent	Yellow Dent	Deep yellow	3	.12	8
31945	Yellow Dent	Surcropper	Dilute yellow	2	.2	5
31946	Surcropper	Yellow Dent	Pale yellow	1	.5	2
31947	Surcropper	Surcropper	White	0	22+	.05
31948	Yellow Dent X Surcropper	Yellow Dent X Surcropper	Deep yellow	3	.2	4
31949	Yellow Dent X Surcropper	Yellow Dent X Surcropper	Dilute yellow	2	.35	3
31950	Yellow Dent X Surcropper	Yellow Dent X Surcropper	Pale yellow	1	.8	1.2
31951	Yellow Dent X Surcropper	Yellow Dent X Surcropper	White	0	22+	.05

CORN MEAL AND HOMINY FEED

In the manufacture of corn meal for human use or for animal feeding, the corn is ground and part of the bran and germ removed. The process varies, so that corn meal may range in character from a meal containing nearly all the grain, with little bran or germ removed, to a highly purified meal containing little bran or germ. The meal containing little bran or germ is usually considered to be of higher commercial quality than the other, and sells for a slightly higher price. Corn meal for human use is usually made from white corn in the South, but in the North it is frequently made from yellow corn. The use of yellow corn meal as a human food on account of its content of vitamin A would no doubt be desirable in many parts of the South, particularly for those who live upon a restricted diet.

Since corn meal is made chiefly from the endosperm of corn, and the endosperm of yellow corn is rich in vitamin A, yellow corn meal should likewise be well supplied with vitamin A.

Tests for vitamin A in corn meal are given in Table 13. Vitamin A in the first two lots (white corn) was determined by the ration method. There appear to be larger amounts of vitamin A in the corn meal than in the corn or corn bran or hominy feed.

Table 13.—Vitamin A in corn, corn meal, and milling products.

		Weekly gain of rats.	Grams to one unit vitamin A	Units vitamin A in grams
	White corn meal, unbolted (Palestine)	7.2	.....	.....
	Pearl meal from the above	12.8	.....	.....
	Corn bran from the above	8.0	.....	.....
	White corn (Dallas)	.....	.....	.....
	Pearl meal from the above	7.9	.....	.....
	La France meal from the above	9.8	.....	.....
	Hominy feed from the above	8.7	.....	.....
30995	Golden corn meal	.....	0.3	3
30996	Yellow granulated corn meal	.....	0.35	3
30997	Yellow corn, Illinois	.....	0.2	5
30998	Yellow hominy feed	.....	0.6	1.5

Vitamin A in the second lot (yellow corn) was determined by the unit method. There seems to be less vitamin A in the meal than in the corn, but the yellow corn meal is well supplied with vitamin A.

COMPOSITION OF CORN

It is known that the chemical composition of corn varies to some extent according to conditions. By proper selection, corn can be grown which is high or low in protein or high or low in fat. According to Pendleton (9), fertilization with nitrate of soda had little effect on the composition of the grain of corn on Iowa soils. Delwiche and Tottingham (2) found the protein in 8 crops of corn grown at Ashland and at

Madison, Wisconsin, to vary from 9.4 to 13.8 per cent, with an average difference of 0.4 per cent of protein in favor of Ashland. This difference is quite small.

The composition of the corn used in the experiments is given in Table 14. Averages are given by varieties and by localities in Tables 15 and 16. No significant variation by varieties is observed. The most significant variation is in the protein content of the corn grown in different localities.

Variation in Protein

The significant figures as related to protein are assembled in Table 17. The substations are arranged in order according to the average protein content of the corn, beginning with the lowest. The figures for 1926, 1927, and 1928 are averaged for several varieties for each substation, but for 1929 there is only one variety, except in case of Temple, for which there are two. The rainfall is also given.

The results from the various localities are reasonably concordant, though wide deviations are to be found some years. The corn grown at Nacogdoches in 1928 contained 4 per cent more protein than that grown in other years. The corn grown at College Station decreased regularly in protein content, from 12.56 to 9.53 per cent, in the four years. The corn at Denton contained 1 per cent more protein than the average in 1928, and that from Beeville, 1 per cent more in 1928 and 1 per cent less in 1926. In spite of these deviations, the protein content of corn is reasonably constant at a given locality.

It is a question how much of the variations shown are due to soil and how much to climatic conditions. It is well known that the composition of cotton seed varies in different sections, containing more protein and less fat in dry sections than in humid sections. It is possible that similar relations exist with reference to the protein of corn and grain sorghums. The correlation coefficient for protein in corn and rainfall (Table 17) is $-.576 \pm .072$. This is a significant correlation.

Variation in Minerals

The lime, magnesia, phosphoric acid, and insoluble ash content of some of the samples of corn grown in 1925 is shown in Table 18. The average lime content was slightly lower in the corn from Iowa Park, Beeville, and Angleton, than in that from the other substations. The magnesia was fairly uniform. The phosphoric acid was lower in corn from Beeville and Nacogdoches than in that from the other stations.

Table 14.—Percentage composition of corn arranged by substations.

Laboratory No.	Where grown and variety	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Water	Ash
	Substation No. 3, Angleton, Texas.						
25851	Chisholm	8.93	4.49	2.18	74.02	9.20	1.18
25852	Hastings Prolific	8.79	4.81	2.05	74.46	8.82	1.07
25853	Brazos White	8.93	4.49	2.16	73.60	9.75	1.07
25854	Oklahoma White Wonder	8.94	4.25	2.05	74.78	8.89	1.09
25855	Tuxpan	10.30	4.88	1.92	72.67	8.90	1.33
25856	Virginia White Dent	9.53	4.82	2.01	73.94	8.58	1.12
25857	Surcropper	9.73	4.90	2.05	74.31	7.81	1.20
25858	Fentress Strawberry	8.87	4.43	2.13	75.07	8.20	1.30
25859	Ferguson Yellow Dent	9.10	4.33	2.13	74.47	8.74	1.23
25860	Thomas	10.78	5.11	2.27	71.77	8.85	1.22
	1926—Average—10	9.39	4.66	2.09	73.91	8.78	1.19
	Substation No. 1, Beeville, Texas.						
25925	Chisholm	11.53	3.78	2.25	73.43	7.83	1.18
25926	Surcropper	11.45	4.35	2.12	73.67	7.22	1.19
25927	Reese's Drouth Resister	10.46	4.30	2.40	72.92	8.74	1.18
25928	Horton Corn	11.21	3.72	2.84	72.36	8.69	1.18
25929	Oklahoma White Wonder	10.63	4.18	2.29	74.88	6.85	1.17
25930	Hastings Prolific	10.88	4.20	2.04	72.02	9.84	1.02
25931	Fentress Strawberry	10.53	3.98	2.37	72.83	9.20	1.09
25932	Ferguson Yellow Dent	11.43	4.10	2.36	72.19	8.78	1.14
	1926—Average—8	11.02	4.08	2.33	73.04	8.39	1.14
	Substation No 4, Beaumont, Texas.						
25839	Tuxpan	10.06	4.45	2.03	74.03	8.17	1.26
25840	Ferguson Yellow Dent	9.70	4.71	2.10	73.79	8.54	1.16
25841	Chisholm	9.76	4.48	2.10	74.42	8.06	1.18
25842	Hastings Prolific	9.48	4.66	2.05	74.01	8.74	1.06
25843	Surcropper	10.50	4.98	2.31	72.28	8.70	1.23
25844	Fentress Strawberry	10.19	4.16	2.31	73.62	8.54	1.18
25845	Thomas	10.35	5.33	2.22	71.90	8.98	1.22
	1926—Average—7	10.06	4.68	2.16	73.42	8.53	1.18
	Main Station Farm, College Station, Texas.						
26201	Strawberry	12.21	4.13	2.17	70.03	10.12	1.34
26202	Ferguson Yellow Dent	12.07	4.47	1.93	71.28	8.83	1.42
26203	Chisholm	13.41	4.35	2.09	70.65	8.03	1.47
	1926—Average—3	12.56	4.32	2.10	70.65	8.99	1.41

	Substation No. 6, Denton, Texas.						
25792	Thomas	12.37	3.46	2.29	70.46	9.97	1.45
25793	Oklahoma White	12.24	4.38	2.27	70.85	8.79	1.47
25794	Ferguson Yellow Dent	12.72	4.53	2.23	70.72	8.32	1.48
25796	Surcropper	12.80	4.59	2.32	69.73	9.06	1.50
25797	Bloody Butcher	12.80	4.60	2.20	70.32	8.65	1.43
25798	Chisholm	12.73	4.62	2.12	71.00	8.09	1.44
25799	Strawberry	13.69	4.74	2.34	69.35	8.35	1.53
25800	Brazos White	12.84	4.57	2.21	70.57	8.27	1.54
	1926—Average—8	12.77	4.44	2.25	70.35	8.69	1.48
	Substation No. 8, Lubbock, Texas.						
26136	Mexican June	12.25	5.16	2.26	68.82	10.09	1.42
26137	Fentress Strawberry	12.14	4.54	2.00	70.64	9.37	1.31
26138	Surcropper	11.56	4.95	2.18	71.15	8.92	1.24
26139	Thomas	12.54	4.92	2.14	70.83	8.21	1.36
26140	Chisholm	11.55	4.68	2.06	70.93	9.49	1.29
26141	Pioneer or Squaw	11.58	4.56	2.08	71.33	9.18	1.27
26142	Ferguson Yellow Dent	12.23	4.66	2.14	70.56	9.18	1.23
26143	Dwarf Mexican June	12.18	4.80	2.01	70.01	8.63	1.37
26144	Silvermine	11.88	4.78	2.34	69.95	9.65	1.40
	1926—Average—9	12.21	4.78	2.13	70.47	9.19	1.32
	Substation No. 16, Iowa Park, Texas.						
25919	Surcropper	10.23	4.21	2.21	72.64	8.36	2.35
25920	Fentress Strawberry	10.94	4.16	1.98	73.13	8.39	1.40
25921	Horton	9.77	4.04	1.99	73.39	9.41	1.40
25922	Ferguson Yellow Dent	9.98	4.33	1.89	73.81	8.73	1.26
25923	Mexican June	10.58	4.37	2.25	73.16	8.16	1.48
25924	Chisholm	10.50	4.11	2.10	74.32	7.62	1.35
	1926—Average—6	10.33	4.20	2.07	73.41	8.45	1.54
	Substation No. 11, Nacogdoches, Texas.						
25940	Yellow Dent	8.50	4.48	1.95	75.65	8.30	1.12
25941	Brazos White	7.88	4.56	2.11	75.90	8.44	1.11
25942	Horton	7.22	4.69	2.31	76.70	8.10	.98
25943	Fentress Strawberry	8.51	4.31	2.01	75.90	8.11	1.16
25944	Hastings Prolific	8.89	4.70	2.00	74.53	8.83	1.05
25945	Oklahoma White	7.86	4.26	1.37	76.23	9.24	1.04
25946	Blue Grain	9.50	4.56	2.31	73.27	9.27	1.09
25947	Surcropper	8.76	4.78	2.25	75.11	8.03	1.07
25948	Thonfas	8.03	5.04	2.34	74.78	8.76	1.05
25949	Chisholm	8.35	4.24	1.98	76.71	7.68	1.04
25950	Nacogdoches	8.22	4.25	2.09	75.96	8.55	.93
	1926—Average 11	8.33	4.53	2.06	75.52	9.33	1.05

Table 14.—Percentage composition of corn arranged by substations—Continued.

Laboratory No.	Where grown and variety	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Water	Ash
	Substation No. 2, Troup, Texas.						
25753	Hastings Prolific	9.98	4.81	2.10	73.75	8.07	1.29
25754	Ferguson Yellow Dent	10.50	4.69	1.99	73.18	8.31	1.33
25755	Surcropper	11.26	4.78	2.20	71.62	8.66	1.48
25756	Bloody Butcher	10.37	4.52	2.23	72.91	8.61	1.36
25757	Fentress Strawberry	9.86	4.29	2.17	73.01	9.36	1.31
25758	Oklahoma White Wonder	10.17	4.33	2.30	72.57	9.26	1.37
25759	Chisholm	10.24	4.87	2.04	73.42	8.03	1.40
25760	Thomas	10.82	5.30	2.33	73.07	7.05	1.43
	1926—Average—8	10.40	4.69	2.17	72.94	8.42	1.37
	Substation No. 3, Angleton, Texas.						
28635	Fentress Strawberry	9.28	4.57	2.05	72.31	10.82	.97
28636	Ferguson Yellow Dent	10.09	4.64	2.00	71.97	10.31	.99
28637	Hastings Prolific	9.28	4.57	1.94	72.64	10.67	.90
28638	Oklahoma White Wonder	9.64	3.38	1.98	73.72	10.33	.95
28639	Chisholm	9.21	4.03	1.98	73.81	10.09	.88
28640	Surcropper	10.29	4.94	2.07	71.56	9.97	1.17
	1927—Average—6	9.63	4.36	2.00	72.67	10.37	.98
	Substation No. 1, Beeville, Texas.						
29037	Fentress Strawberry	13.45	4.07	2.09	70.52	8.81	1.06
29038	Ferguson Yellow Dent	11.96	4.12	2.07	70.12	10.76	.97
29039	Surcropper	12.23	4.15	2.19	69.83	10.48	1.12
29040	Chisholm	12.18	3.68	2.22	70.15	10.72	1.05
29041	Hastings Prolific	12.69	3.85	2.23	69.68	10.57	.98
29042	Oklahoma White Wonder	12.66	4.00	2.40	70.46	9.47	1.01
	1927—Average—6	12.53	3.98	2.20	70.13	10.14	1.03
	Main Station Farm, College Station, Texas.						
29134	Strawberry	11.87	3.80	2.56	68.80	11.65	1.32
29135	Hastings Prolific	11.21	3.60	2.96	70.33	10.53	1.37
29136	Nacogdoches	11.45	4.05	2.85	69.72	10.51	1.42
29137	Surcropper	12.27	4.33	2.63	69.13	10.12	1.52
29138	White Wonder	11.13	3.25	2.58	70.67	10.93	1.44
29139	Brazos White	11.23	3.81	2.72	69.91	10.98	1.35
29140	Chisholm	10.92	4.21	2.16	70.85	10.67	1.19
29141	Thomas	10.86	4.47	2.48	70.37	10.61	1.21
29142	Ferguson Yellow Dent	12.71	4.26	2.40	69.17	10.09	1.37
29143	Horton	11.27	3.93	2.81	71.11	9.63	1.25

29144	White Dent	11.15	4.51	2.45	69.56	10.92	1.41
29229	Yellow corn—No analysis						
	1927—Average—11	11.46	4.02	2.60	69.97	10.60	1.35
	Substation No. 6, Denton, Texas.						
28650	Surcropper	11.38	4.93	2.48	71.52	8.32	1.37
28651	Ferguson Yellow Dent	11.98	4.01	2.10	70.92	9.67	1.32
	1927—Average—2	11.68	4.47	2.29	71.22	9.00	1.35
	Substation No. 16, Iowa Park, Texas.						
29050	Oklahoma Yellow Dent	10.81	4.42	2.00	70.54	10.91	1.32
29051	Mexican June	13.31	3.94	2.27	67.75	11.09	1.64
	1927—Average—2	12.06	4.18	2.14	69.15	11.00	1.48
	Substation No. 8, Lubbock, Texas.						
29031	Surcropper	9.79	4.26	1.90	73.22	9.84	.99
29032	Ferguson Yellow Dent	10.14	4.19	1.96	72.54	9.95	1.22
29033	Fentress Strawberry	10.62	4.21	2.05	72.32	9.64	1.16
	1927—Average—3	10.18	4.22	1.97	72.69	9.81	1.12
	Substation No. 11, Nacogdoches, Texas.						
28978	Fentress Strawberry	7.17	3.94	2.05	74.59	11.26	.99
28979	Hastings Prolific	7.50	4.73	1.85	74.63	10.32	.97
28980	Oklahoma White Wonder	9.11	4.94	2.14	72.46	10.36	.99
28981	Surcropper	7.51	4.06	2.12	74.67	10.67	.97
28982	Chisholm	8.95	4.28	1.73	73.06	10.50	1.48
28983	Ferguson Yellow Dent	8.58	4.10	2.04	74.01	10.21	1.06
	1927—Average—6	8.14	4.34	1.99	73.90	10.55	1.08
	Substation No. 2, Troup, Texas.						
28644	Hastings Prolific	9.99	4.81	2.23	70.94	10.75	1.28
28645	Ferguson Yellow Dent	9.34	4.48	2.26	72.67	9.95	1.30
28646	Chisholm	8.21	4.47	1.89	74.02	10.21	1.20
28647	Fentress Strawberry	9.47	4.50	2.32	72.18	10.26	1.27
28648	Surcropper	9.29	4.64	2.25	72.91	9.42	1.49
28649	Oklahoma White Wonder	8.44	3.78	2.29	75.61	8.65	1.23
	1927—Average—6	9.12	4.45	2.21	73.06	9.87	1.30
	Substation No. 3, Angleton, Texas.						
30483	Yellow Creole	10.98	3.89	1.98	70.86	11.04	1.25
30484	Ferguson Yellow Dent	9.91	4.09	2.09	72.36	10.39	1.16
30485	Fentress Strawberry	10.29	3.80	2.15	72.42	10.16	1.18
	1928—Average—3	10.39	3.93	2.07	71.88	10.53	1.20

Table 14.—Percentage composition of corn arranged by substations—Continued.

Laboratory No.	Where grown and variety	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Water	Ash
	Substation No. 1, Beeville, Texas.						
30270	Nicholson's Giant Yellow	12.70	3.42	2.32	70.54	9.58	1.44
30172	Wood's Golden Harvest	13.16	3.61	2.36	69.69	9.68	1.50
30272	Reuter's Improved Golden Dent	13.12	3.06	2.52	70.18	9.66	1.46
30273	Ferguson Yellow Dent	13.09	3.41	2.48	70.22	9.38	1.42
30274	Fentress Strawberry	13.66	3.00	2.45	68.88	10.62	1.39
30275	Bloody Butcher	13.55	3.15	2.25	69.75	10.04	1.26
	1928—Average—6	13.21	3.28	2.40	69.88	9.83	1.41
	Substation No. 12, Chillicothe, Texas.						
30842	Surcropper	12.27	4.61	2.41	69.41	9.82	1.48
	Main Station Farm, College Station, Texas.						
30491	Yellow Creole	10.76	4.01	2.45	72.76	8.85	1.17
30492	Ferguson Yellow Dent	11.01	4.15	2.40	72.43	8.76	1.25
	1928—Average—2	10.89	4.08	2.43	72.60	8.81	1.21
	Substation No. 6, Denton, Texas.						
30384	Strawberry	11.61	4.17	2.29	70.54	10.10	1.29
30385	Bloody Butcher	12.08	3.84	2.10	68.74	11.91	1.33
30386	Wright Yellow Dent	10.90	4.19	1.96	72.38	9.27	1.30
30373	Pilgrim Yellow Dent	11.62	3.79	2.15	70.46	10.51	1.47
	1928—Average—4	11.55	4.00	2.13	70.53	10.45	1.35
	Substation No. 16, Iowa Park, Texas.						
30719	Bloody Butcher	12.90	3.77	2.32	71.04	8.75	1.22
30720	Oklahoma Yellow Dent	12.92	4.23	2.20	70.64	8.54	1.45
30721	Ferguson Yellow Dent	12.95	4.03	2.28	70.64	8.73	1.37
	1928—Average—3	12.93	4.01	2.27	70.77	8.67	1.35
	Substation No. 11, Nacogdoches, Texas.						
30482	Yellow Creole	12.22	4.78	2.02	70.20	9.35	1.43
	Substation No. 5, Temple, Texas.						
30310	Yellow Dent	10.53	3.91	2.19	72.07	10.09	1.21
30311	Bloody Butcher	10.29	4.25	2.22	71.98	9.96	1.30
	1928—Average—2	10.41	4.08	2.21	72.03	10.03	1.26

	Substation No. 2, Troup, Texas.						
30213	Fentress Strawberry	9.56	4.19	2.47	75.25	7.18	1.35
30214	Giant Yellow	9.76	4.75	2.13	75.67	6.46	1.23
30215	Golden Harvest	9.84	4.89	2.09	73.93	7.95	1.30
30216	Reuter's Improved Golden	10.10	4.25	2.50	74.81	7.03	1.31
30217	Ferguson Yellow Dent	9.58	4.35	2.12	75.37	7.24	1.34
	1928—Average—5	9.77	4.49	2.26	75.01	7.17	1.31
	Substation No. 15, Weslaco, Texas.						
30493	Ferguson Yellow Dent	10.77	4.29	2.07	71.39	10.13	1.35
30494	Yellow Creole	11.70	5.11	2.01	70.71	8.96	1.51
30495	Fentress Strawberry	11.07	3.94	2.26	72.42	8.92	1.39
30496	Improved Golden	11.47	4.33	2.18	71.08	9.52	1.42
	1928—Average—4	11.25	4.42	2.13	71.40	9.38	1.42

Table 15.—Average percentage composition of corn, by substations.

Location and number of substation	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Water	Ash	Number averaged	Year grown
Angleton, No 3	9.39	4.66	2.09	73.91	8.78	1.19	10	1926
Beaumont, No. 4	10.06	4.68	2.16	73.42	8.53	1.18	7	1926
Beeville, No. 1	11.02	4.08	2.33	73.04	8.39	1.14	8	1926
College (Main Station)	12.56	4.32	2.10	70.65	8.99	1.41	3	1926
Denton, No. 6	12.77	4.44	2.25	70.35	8.69	1.48	8	1926
Lubbock, No. 8	12.21	4.78	2.13	70.47	9.19	1.32	9	1926
Iowa Park, No. 16	10.33	4.20	2.07	73.41	8.45	1.54	6	1926
Nacogdoches, No. 11	8.33	4.53	2.06	75.52	9.33	1.05	11	1926
Troup, No. 2	10.40	4.69	2.17	72.94	8.42	1.37	8	1926
Angleton, No. 3	9.63	4.36	2.00	72.67	10.37	.98	6	1927
Beeville, No. 1	12.53	3.98	2.20	70.13	10.14	1.03	6	1927
College (Main Station)	11.46	4.02	2.60	69.97	10.60	1.35	11	1927
Denton, No. 6	11.68	4.47	2.29	71.22	9.00	1.35	2	1927
Iowa Park, No. 16	12.06	4.18	2.14	69.15	11.00	1.48	2	1927
Lubbock, No. 8	10.18	4.22	1.97	72.69	9.81	1.12	3	1927
Nacogdoches, No. 11	8.14	4.34	1.99	73.90	10.55	1.08	6	1927
Troup, No. 2	9.12	4.45	2.21	73.06	9.87	1.30	6	1927
Angleton, No. 3	10.39	3.93	2.07	71.88	10.53	1.20	3	1928
Beeville, No. 1	13.21	3.28	2.40	69.88	9.83	1.41	6	1928
Chillicothe, No. 12	12.27	4.61	2.41	69.41	9.82	1.48	1	1928
College (Main Station)	10.89	4.08	2.43	72.60	8.81	1.21	2	1928
Denton, No. 6	11.55	4.00	2.13	70.53	10.45	1.35	4	1928
Iowa Park, No. 16	12.93	4.01	2.27	70.77	8.67	1.35	3	1928
Nacogdoches, No. 11	12.22	4.78	2.02	70.20	9.35	1.43	1	1928
Temple, No. 5	10.41	4.08	2.21	72.03	10.03	1.26	2	1928
Troup, No. 2	9.77	4.49	2.26	75.01	7.17	1.31	5	1928
Weslaco, No. 15	11.25	4.42	2.13	71.40	9,38	1.42	4	1928

Variety	Number averaged	Protein	Ether extract	Crude fibre	Nitrogen-free extract	Water	Ash	Year
Chisholm	9	10.65	4.41	2.12	73.20	8.22	1.30	1925
	5	9.89	4.13	2.00	72.38	10.44	1.16	1926
Ferguson Yellow Dent	9	10.69	4.48	2.08	72.86	8.62	1.27	1925
	7	10.69	4.26	2.12	71.63	10.13	1.18	1926
	6	11.22	4.05	2.24	72.07	9.11	1.32	1927
Surcropper	8	10.79	4.69	2.21	72.56	8.35	1.41	1925
	7	10.39	4.47	2.23	71.83	9.83	1.23	1926
Fentress Strawberry	9	11.08	4.33	2.17	72.15	8.90	1.37	1925
	6	10.31	4.18	2.19	71.48	10.41	1.13	1926
	4	11.15	3.73	2.33	72.24	9.22	1.33	1927
Thomas	7	10.95	4.81	2.28	71.93	8.27	1.26	1925
Hastings Prolific	5	9.60	4.63	2.04	73.77	8.86	1.10	1925
	5	10.13	4.31	2.24	71.64	10.57	1.10	1926
Oklahoma White Wonder	5	9.97	4.28	2.06	73.39	8.61	1.22	1925
	5	10.19	3.87	2.28	72.60	9.94	1.12	1926
Brazos White	3	9.89	4.54	2.16	73.36	8.82	1.24	1925
Horton	3	9.40	4.15	2.38	74.15	8.73	1.19	1925
Mexican June	3	11.67	4.77	2.17	71.00	8.96	1.42	1925
Bloody Butcher	2	11.59	4.56	2.22	71.62	8.63	1.40	1925
	4	12.21	3.75	2.22	70.38	10.17	1.28	1927
Yellow Creole	3	11.63	4.59	2.00	70.59	9.78	1.40	1927

Table 17.—Average protein content of corn compared with rainfall.

Location	Protein, per cent					Rainfall in inches. January to July, inclusive			
	1926	1927	1928	1929	Average	1926	1927	1928	1929
Beaumont, No. 4	10.1	.....	.....	7.3	8.7	33.7	.....	.....	37.4
Nacogdoches, No. 11	8.3	8.1	12.2	8.2	9.2	36.2	33.1	26.6	33.1
Angleton, No. 3	9.4	9.6	10.4	9.4	9.7	25.2	14.7	16.9	28.9
Troup, No. 2	10.4	9.1	9.8	10.3	9.9	31.3	28.0	27.1	26.2
Temple, No. 5	.....	.....	10.4	10.1	10.2	.....	.....	18.3	31.7
Weslaco, No. 15	.....	.....	11.3	10.9	11.1	.....	.....	14.1	16.8
College Station (Main Station)	12.6	11.5	10.9	9.5	11.1	26.0	27.7	20.7	36.4
Lubbock, No. 8	12.2	10.2	.....	11.4	11.3	11.3	6.6	.....	11.0
Denton, No. 6	12.8	11.7	11.6	11.1	11.8	24.1	20.2	18.5	18.4
Chillicothe, No. 12	.....	.....	12.3	11.9	12.1	.....	.....	16.5	19.6
Iowa Park, No. 16	10.3	12.1	12.9	13.0	12.1	22.5	19.4	23.4	19.1
Beeville, No. 1	11.0	12.5	13.2	11.8	12.1	19.3	13.5	11.8	25.6

Table 18.—Mineral composition of corn, 1926.

No.	Where grown and variety	Insoluble Ash	Lime	Magnesia	Phosphoric Acid	Iron
	Substation No. 16, Iowa Park, Texas.					
25920	Fentress Strawberry	.22	.02	.20	.64	.....
25921	Horton	.08	.02	.20	.63	.....
25922	Ferguson Yellow Dent	.05	.02	.18	.57	.....
25923	Mexican June	.09	.04	.20	.63	.....
25924	Chisholm	.05	.02	.20	.65	.....
	Average (5)	.10	.02	.20	.62	.....
	Substation No. 1, Beeville, Texas.					
25925	Chisholm	.30	.02	.17	.56	.....
25926	Surcropper	.42	.02	.18	.46	.....
25927	Reese's Drouth Resister	.20	.02	.18	.48	.....
25928	Horton	.14	.02	.18	.45	.....
25929	Oklahoma White Wonder	.16	.02	.17	.47	.....
25930	Hastings Prolific	.40	.02	.16	.44	.....
25931	Fentress Strawberry	.21	.02	.17	.50	.....
25932	Ferguson Yellow Dent	.20	.02	.17	.50	.....
25933	Thomas	.18	.02	.17	.43	.....
	Average (9)	.25	.02	.17	.48	.....
	Substation No. 11, Nacogdoches, Tex.					
25940	Yellow Dent	.22	.02	.16	.48	.....
25941	Brazos White	.30	.08	.17	.53	.....
25942	Horton	.16	.02	.16	.51	.....
25943	Fentress Strawberry	.23	.03	.16	.60	.....
25944	Hastings Prolific	.18	.02	.16	.50	.....
25945	Oklahoma White	.22	.02	.16	.51	.....
25946	Blue Grain	.46	.02	.16	.47	.....
25947	Surcropper	.25	.02	.15	.41	.....
25948	Thomas	.16	.02	.16	.46	.....
25949	Chisholm	.14	.02	.15	.44	.....
25950	Nacogdoches	.15	.07	.26	.44	.....
	Average (11)	.22	.03	.17	.49	.....
	Substation No. 2, Troup, Texas.					
25753	Hastings Prolific	.05	.03	.17	.66	.0058
25754	Ferguson Yellow Dent	.08	.03	.18	.65	.0065
25755	Surcropper	.05	.04	.19	.75	.0039
25756	Bloody Butcher	.06	.06	.18	.70	.0047
25757	Fentress Strawberry	.02	.02	.17	.66	.0040
25758	Oklahoma White Wonder	.05	.03	.20	.72	.0028
25759	Chisholm	.03	.02	.18	.74	.0031
25760	Thomas	.04	.01	.19	.73	.0035
	Average (8)	.05	.03	.18	.70	.0043
	Substation No. 6, Denton, Texas.					
25793	Oklahoma White Wonder	.02	.02	.20	.....	.0035
25795	Local Squaw	.17	.03	.21	.....	.0036
25796	Surcropper	.10	.03	.20	.....	.0075
25797	Bloody Butcher	.09	.04	.21	.....	.0074
25798	Chisholm	.08	.03	.20	.....	.0031
25799	Strawberry	.23	.03	.22	.72	.0036
25800	Brazos White	.05	.02	.20	.74	.0050
	Average (7)	.11	.03	.21	.73	.0048
	Substation No. 4, Beaumont, Texas.					
25839	Tuxpan	.12	.05	.16	.52	.....
25840	Ferguson Yellow Dent	.11	.02	.17	.54	.....
25841	Chisholm	.05	.03	.17	.61	.....
25842	Hastings Prolific	.06	.02	.16	.59	.....
25843	Surcropper	.05	.02	.17	.60	.....
25844	Fentress Strawberry	.06	.02	.15	.67	.....
25845	Thomas	.04	.02	.18	.65	.....
	Average (7)	.07	.03	.17	.60	.....

Table 18.—Mineral composition of corn, 1926—Continued.

No.	Where grown and variety	Insoluble Ash	Lime	Magnesia	Phosphoric Acid	Iron
	Substation No. 3, Angleton, Texas.					
25852	Hastings Prolific	.05	.02	.16	.51	.....
25853	Brazos White	.06	.02	.16	.51	.....
25854	Oklahoma White Wonder	.07	.02	.16	.51	.....
25855	Tuxpan	.09	.02	.19	.71	.....
25860	Thomas	.04	.02	.18	.66	.....
	Average (5)	.06	.02	.17	.58	.....

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SUMMARY

The diet of man and animals should furnish sufficient energy, proteins, vitamins, and minerals such as phosphoric acid, lime, magnesia, soda, chlorine, iron, copper, iodine, and fluorine. Deficiencies in diet may cause retardation of growth in young animals or deficient production of milk, eggs, etc., or diminished health or vigor, or diseases such as xerophthalmia, anemia, rickets, pellagra, or goiter.

Vitamins are organic compounds which are present in small amounts in foods and are essential to the health of animals. The various vitamins are briefly discussed.

Vitamin A is an organic compound essential in very small amounts to animal life. It is found in such foods as green vegetables, butter and corn; it is much more abundant in yellow corn than in white corn.

The quantity of vitamin A in foods is measured by experiments on animals, especially rats.

Methods of care and breeding of rats are described. Selection of rats resulted in a decided increase in uniformity.

Two methods of estimating vitamin A were tested. The unit method (Sherman-Munsell) was found to be much superior to the ration method.

Vitamin A was estimated in 20 samples of Ferguson yellow dent corn, grown in 11 different localities and during three seasons, and in 19 samples of other varieties of yellow corn grown in various localities. They contained about the same amount of vitamin A, one gram containing 2.5 to 8 units.

Varieties of variegated and of red corn tested (18 samples) were Fentress Strawberry and Bloody Butcher. One gram of Strawberry corn contained 0.9 to 2.9 units of vitamin A while one gram of the Bloody Butcher contained 1.8 to 2.5 units. Both varieties contained less vitamin A than yellow corn and were more variable.

The yellow and the red and the variegated corn grown in 1928 contained the most vitamin A, that in 1927 came next, and that grown in 1926 contained the lowest amount.

White corn contained so little vitamin A that the amount could be estimated only approximately. It usually contained only one unit in 25 to 35 grams (or more) of corn. A few samples contained a unit in 2 to 5 grams, probably due to crossing with yellow corn.

The units of vitamin A in crosses of white and of yellow corn were approximately in proportion to the number of genetic factors present for the yellow endosperm. Samples of corn from mixed pollination containing the yellow genetic factor 1:2:3 contained vitamin A in the proportions 2.5:5:7 in 1928 and 2:5:8 in 1929. Segregations from a white and a yellow corn contained less vitamin A for the corresponding number of genetic factors than the seed from the mixed pollinations, but the ratios were approximately the same.

Yellow corn and yellow corn meal are rich in vitamin A.

Different varieties of corn showed no significant variation in content of protein, fat, nitrogen-free extract, ash, lime, magnesia, or phosphoric acid.

Corn grown in different localities showed variations in lime and phosphoric acid, and especially in the protein content.

Corn grown near Beaumont was lowest in protein and that near Beeville was highest. The correlation of protein with rainfall was $-0.576 \pm .072$, which is a significant relation.

The average lime content was slightly lower in corn grown at Iowa Park, Beeville, and Angleton than at the other localities.

The phosphoric acid was slightly lower in the corn from Beeville and Nacogdoches than from the other places.

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